# The Engineer

LONDON, FRIDAY, MAY 16, 1941.


## PUBLIC NOTICES

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TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

**IMPORTANT**

**Advertisers in Situations Open Column should make themselves acquainted with the terms of**

**STATUTORY RULES & ORDERS**
**1940 No. 877**
**RESTRICTION ON ENGAGEMENT ORDER**

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THE Post You Are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing Your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for a cost of Four Lines, 4s.; 1s. for each Additional Line. There is no better way of covering so large a field for such a small charge.

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## The Engineer

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## IMPORTANT NOTICE

**All correspondence dealing with Editorial, Advertising and Subscription Matters should be addressed to: 28, ESSEX STREET, STRAND, LONDON, W.C. 2**

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## PATENTS

IT is DESIRED to SECURE the Full COMMERCIAL DEVELOPMENT in the United Kingdom of BRITISH PATENT No. 478,225, which relates to "Pipe Couplings," either by way of the GRANT of LICENCES or otherwise on terms acceptable to the Patentees.—Interested parties desiring a copy of the patent specification and further particulars should apply to STEVENS, LANGNER, PARRY & ROLLINSON, 5 to 9, Quality Court, Chancery Lane, London, W.C.2. 7416 H

IT is DESIRED to SECURE the Full COMMERCIAL DEVELOPMENT in the United Kingdom of BRITISH PATENT No. 443,015, which relates to "Fuel Injection for Internal Combustion Engines," either by way of the GRANT of LICENCES or otherwise on terms acceptable to the Patentees.—Interested parties desiring a copy of the patent specification and further particulars should apply to STEVENS, LANGNER, PARRY & ROLLINSON, 5 to 9, Quality Court, Chancery Lane, London, W.C.2. 7417 H

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THE PROPRIETOR of BRITISH PATENT No. 423,243, dated December 17th, 1932, relating to to "Gun Carriages," is DESIROUS of ENTERING into ARRANGEMENTS by way of a licence or otherwise on reasonable terms for the purpose of EXPLOITING the above PATENT and ensuring its practical working in Great Britain.—Inquiries to SINGER, EHLERT, STERN and CARLBERG, Steger Building, Chicago, Illinois. 7412 H

THE PROPRIETORS of LETTERS PATENT Nos. 441,177 and 459,336, relating to the "Production of Metallic Articles from Powders," DESIRE to GRANT LICENCES under the patents to interested parties on reasonable terms for the purpose of EXPLOITING the same and ensuring their full commercial development and practical working in this country.—Inquiries to be addressed to CRUIKSHANK and FAIRWEATHER, 29, Southampton Buildings, London, W.C.2. 7411 H


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# The Engineer

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*Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of* THE ENGINEER.

**Postal Address,**
**28, Essex Street, Strand, London, W.C.2.**

**Teleg. Address,**
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## MACHINERY, &c., WANTED

WANTED, VULCANISED STEEL BASKET, 42in. dia., in good condition for Broadbent Hydro-extractor.—SMITH, 29, Spelman Street, E.1. 'Phone, BIS 1422. P3280 F

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**For continuation of Small Advertisements see page 72**

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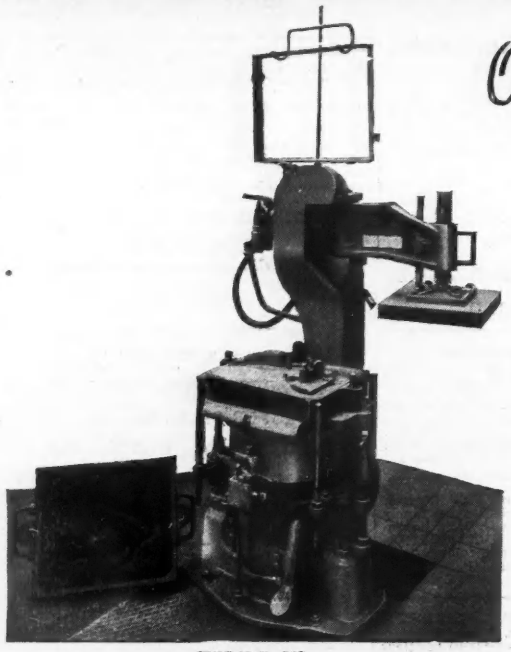

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# A Seven-Day Journal

## Enemy Night Bomber and Fighter Losses in May

THE official returns of the Air Ministry and the Ministry of Home Security show that up to Wednesday, May 14th, German bombers and fighters shot down during the month of May in this country and over Northern France number 137. Of these, 112 were accounted for by fighters of the Royal Air Force, twenty-two were destroyed by anti-aircraft gunfire, two were brought down by contact with anti-aircraft balloons, and one, on Sunday night, May 11th, by unspecified means. Last week the combined losses of German and Italian aircraft, for the third time in a month, rose to three figures. In the week which ended at dusk on Saturday, May 10th, it is reported that a total of 148 aircraft belonging to Germany and Italy were destroyed by the Royal Air Force in Europe and in the Middle East. Against that heavy loss the Royal Air Force losses amounted to only forty-eight aircraft, from which several of the pilots landed safely. In addition to Axis machines destroyed mentioned above, the Royal Air Force put out of action thirty-seven Iraki aircraft. In the night raids over Great Britain full advantage was taken by our fighters of the moonlight nights, and the totals accounted for were sixteen on the night May 3rd-May 4th, twenty-four on the night May 7th-May 8th, fourteen on the night May 8th-May 9th, thirty-three on the night May 10th-May 11th and thirteen on the night May 11th-May 12th.

## The Ministry of War Transport

BY an Order in Council, made on Friday, May 9th legal effect was given to the amalgamation of the Ministries of Shipping and Transport, under the new title of the Ministry of War Transport. As recorded briefly in one of last week's Journal notes, Mr. F. J. Leathers, who is to be made a baron, accordingly becomes Minister of War Transport. All the present functions of the Ministries of Shipping and Transport are, by the Order in Council, transferred to the present new Ministry, and the question as to whether any of them should ultimately be transferred elsewhere is under consideration. It is announced that Colonel J. J. Llewellin and Sir Arthur Salter are to be appointed secretaries to the Ministry of War Transport. As already announced, Colonel Llewellin will represent the Minister in the House of Commons, Sir Arthur Salter being at present in the United States of America on an official mission connected with shipping matters. Sir Cyril Hurcomb, who has hitherto held the office of Director-General of the Ministry of Shipping, has been appointed Director-General of the new Ministry. The office of Secretary of the Ministry of Transport lapses with the creation of the new Ministry, and Sir Leonard Browett, who held that post, has been attached temporarily to the Treasury for general service. At the request, however, of Mr. Leathers, the Minister of War Transport, Sir Leonard will be available for the time being to assist in the work of the new Ministry.

## Institution of Electrical Engineers

LAST Thursday, May 8th, the thirty-second Kelvin Lecture was presented by Dr. S. Chapman, F.R.S., at the Institution of Electrical Engineers. The subject chosen was "Electrical Works by Helios" or "The Sun and the Ionosphere." Delivery of the lecture was preceded by the presentation by the President, on behalf of the Engineering Institute of Canada, of the Sir John Kennedy Medal to Lieut.-General A. G. L. MacNaughton and of the Institution's own Faraday Medal to Dr. A. P. M. Fleming. The President, Mr. Beard, said that the Institution deemed it a great privilege to make the presentation of the Sir John Kennedy Medal. The Medal was awarded as occasion merited to corporate members of the Institute of Canada "in recognition of outstanding merit in the profession or of a noteworthy contribution to the science of engineering." General MacNaughton saw service in the 1914–18 war and on his return to Canada held a number of important posts, becoming Chief of General Staff in 1929. In 1935 he was made President of the Canadian National Research Council. In co-operation with Col. W. A. Steel he was concerned in the development of the cathode ray direction finder, and he also promoted work on high-voltage investigations. In 1939 he was technical adviser to a delegation of Canadian manufacturers to Great Britain, which came to this country to investigate the possibility of producing munitions in Canadian plants. General MacNaughton is now officer commanding the Canadian Forces in Great Britain. Dr. Fleming, the recipient of the Faraday Medal, has been particularly concerned with education and research. He served on Board of Education Committees, is Chairman of the BEAMA Committee on Education, and serves on the Committee of Education of the F.B.I. In 1939 he was Chairman of the Education Section of the British Association. On the research side he was the creator of the British Westinghouse research department, and as the director of the research department at Trafford Park he has seen many fundamental researches pursued in widely differing scientific fields. He gave great help to the Cavendish Laboratory in Dr. Kapitza's early experiments in the production of intense magnetic fields. An informal and very pleasant Council luncheon at the Waldorf Hotel preceded the meeting.

## Mercantile Shipping Losses in April

ON Saturday, May 10th, the official figures for the losses of mercantile shipping by enemy action during the month of April were made known. They include 106 ships of 488,124 tons, of which sixty ships of 293,089 tons were British, forty-three ships of 189,473 tons Allied, and three ships of 5562 tons neutral. Included in the figure of 488,124 tons are the losses incurred in the recent operations in the Mediterranean, which amounted to no less than 187,054 tons, a large proportion of which was Greek tonnage destroyed in Greek ports, and which, the Admiralty points out, was not lost in direct attacks on shipping. Referring further to the April total of 488,124 tons, it may be recalled that the Germans claimed to have sunk during the month of April a total of 1,144,995 tons, and the Italians 74,000 tons, making a total of 1,218,995 tons, or more than 2½ times the actual losses. With regard to enemy losses, it is estimated by the Admiralty that the total tonnage lost by the enemy to date—by capture, by sinking, or by scuttling to avoid capture—is 2,912,000 tons, and is made up as follows:—Losses of German ships, 1,756,000 tons; losses of Italian ships, 1,090,000 tons; and tonnage useful to the enemy, 66,000. On March 25th it was announced by the Admiralty that the total loss of enemy shipping was to date 2,300,000 tons. This means that in the last six weeks enemy tonnage has been reduced by over 600,000. The Admiralty has also issued the following list of monthly figures of losses, revised to date, on a calendar month basis, since May, 1940:

| Month of loss. | British. | | Allied and neutral. | | Total. | |
|---|---|---|---|---|---|---|
| | Ships. | Gross tons. | Ships. | Gross tons. | Ships. | Gross tons. |
| 1940. | | | | | | |
| May ... ... | 31 | 75,151 | 33 | 173,499 | 64 | 248,650 |
| June ... ... | 65 | 269,783 | 63 | 264,119 | 128 | 533,902 |
| July ... ... | 69 | 290,270 | 36 | 115,583 | 105 | 405,853 |
| August ... | 58 | 282,432 | 30 | 105,039 | 88 | 387,471 |
| September | 60 | 307,427 | 32 | 128,126 | 92 | 435,553 |
| October ... | 66 | 299,399 | 30 | 124,217 | 96 | 423,616 |
| November | 65 | 299,816 | 20 | 68,990 | 85 | 368,806 |
| December... | 55 | 230,307 | 17 | 82,890 | 72 | 313,197 |
| 1941. | | | | | | |
| January ... | 41 | 205,473 | 17 | 100,529 | 58 | 306,002 |
| February ... | 68 | 264,423 | 17 | 69,481 | 85 | 334,004 |
| March ... | 81 | 326,631 | 38 | 162,598 | 119 | 489,229 |

## Indian Ocean Naval Operations

ON Friday, May 9th, it was announced by the Admiralty that a German armed merchant cruiser had been intercepted and sunk while acting as a commerce raider in the Indian Ocean, by the cruiser H.M.S. "Cornwall," under the command of Captain P. C. W. Mainwaring, R.N. Twenty-seven British merchant seamen who were held on board the raider as prisoners were rescued. Fifty-three of the German crew of the raider survived and were taken prisoner. It is announced by the Admiralty that H.M.S. 'Cornwall" sustained only superficial damage during the engagement and that her fighting efficiency was in no way impaired. Although full details of the raider have not yet been published, she is believed to be an ex-Hansa liner of some 10,000 gross tons, with a speed of round about 19 knots. It is very likely that in her conversion for raiding operations she was fitted with concealed guns, torpedo tubes and minelaying gear. The announcement seems to indicate that the superficial damage of the "Cornwall" may have been sustained in a fight and that the raider was most likely not scuttled. The "Cornwall," we may recall, is one of five cruisers of the "Kent" class. She was built under the 1924–25 Estimates to the designs of Sir Eustace Tennyson d'Eyncourt and has an overall length of 630ft., a beam of 68ft. 6in. and a draught of 16ft. 3in. Her armament comprises eight 8in. guns, eight 4in. anti-aircraft guns and twenty smaller guns. She is propelled by geared steam turbines of the Parsons type, arranged on four shafts, taking steam from 250 lb. Admiralty type three-drum water-tube boilers and having a designed output of 80,000 S.H.P., corresponding to a trial speed of 31·5 knots. During the trials of these cruisers mean speeds of over 32·5 knots were averaged. This class of ships were all reconstructed during 1935–38 and the armour was increased and the anti-aircraft protection brought up to date. A large hangar and room for additional aircraft were included in the modifications made. About the same time as the sinking of the raider the Australian cruiser H.M.A.S. "Canberra," under the command of Captain H. B. Farncomb, M.V.O., R.N., and the New Zealand squadron cruiser H.M.S. "Leander," under the command of Captain R. H. Bevan, R.N., intercepted a German merchant vessel which had been acting as a supply ship for the sunken raider, and a Norwegian tanker which had been captured by the raider. The supply ship was the 7400-ton merchant ship "Coburg" and the tanker the 7031-ton "Ketty Brovig."

## Registration of Storage Space

IN a Journal note of April 11th we recorded the appointment of Sir Cecil Weir to the office of Controller-General of Factory and Storage Premises. Since that announcement Mr. P. A. Warter has been appointed Controller of Storage. More than 14,000,000 square feet of additional storage space is now required by the various Government Departments for munitions, equipment, valuable raw materials and other essential goods. On Monday, May 12th, the Board of Trade issued the Storage Facilities (Information) Order (S.R. and O., 1941, No. 641), which requires the owners of suitable storage premises in Great Britain to notify the Controller and to give certain information with regard to available premises. Such premises include those of which the floor area is 3000 square feet or more and which have at any time since January 1st, 1938, been used for the purpose of storing goods of any kind, whether or not they are now being used for storage or other purposes. It is requested that owners of such premises should apply as soon as possible, either to their local Chamber of Commerce, any office of the Federation of British Industries, any office of the National Union of Manufacturers, or the Registrar of Factory and Storage Premises at the Board of Trade, Millbank, London, for a form of return upon which the information desired may be entered. This form must be returned completed to the Registrar on or before June 2nd next. Several classes of storage space are excluded from the provisions of the Order. They include garages, farm buildings used solely in connection with agricultural operations, premises used mainly in connection with a factory and situated within one mile from that factory, premises in respect of which a "return of factory premises" has already been made, and premises owned by local authorities and most public utility undertakings, &c. Copies of the Board of Trade Order can now be obtained from H.M. Stationery Office or through any bookseller. It is pointed out that the new Order is the first of its kind and only covers those premises which have a floor area of 3000 square feet and which during the past three years have been used for storage at any time. The returns made under the Order, together with the returns now being collected of empty factory premises, which cannot be used for production will form the basis of a Register of Storage Premises now being compiled.

## Institution of Engineers-in-Charge

RARELY have we heard a better set of speeches than those which followed the annual dinner of the Institution of Engineers-in-Charge on Friday, May 9th at the Holborn Restaurant. We sat down at 5.30, and as it was settled that the function should end not later than eight o'clock, the concert which is a usual feature of these dinners was omitted. Sir Alexander Gibb, the President, is in the North, and the chair was taken by Mr. J. M. Kennedy, Vice-President. His duties were not heavy, but he performed them to perfection. The first toast of the evening was that of "The Institution," which was proposed by Sir Leopold Savile, President of the Institution of Civil Engineers, in an effective speech, which included most aptly a splendid quotation from part of the Masonic rubric. Mr. Kennedy, in his reply, took the opportunity to say something about raids and electricity supply. A good point he made was that overhead conductors could be repaired in a few hours, whilst if underground conductors were bombed in a street it took days to mend them. Then came an admirable speech by Mr. A. Beverley Baxter, M.P., exalting "The British and Allied Mercantile Marine." To it Mr. John Harrison, chairman of J. and C. Harrison, Ltd., shipowners, replied. He gave several examples from his own knowledge of the courage and the humour of British seamen. After that, in response to the toast of "Our Guests and Friends," ingeniously proposed by Mr. C. D. Lightfoot, Chairman of the Institution, Sir Charles Bressey got upon his feet and kept us all laughing for ten minutes. As usual, the last toast was "Our Chairman," entrusted to Mr. A. Sinclair, Vice-Chairman of the Institution. Mr. Kennedy made a suitable acknowledgment, and it being then just upon eight o'clock a dinner, of which Captain Penn and all others concerned may be justly proud, was brought to an end with the National Anthem.

# Facts About the Rifle

By DAVID WEIR, B.Sc.

No. I

IN these days many engineers have been obliged, for the first time in their lives, to become familiar with firearms, particularly with the service rifle. Now by force of habit and training, the engineer will approach this matter of firearms as he would any other. He will endeavour to find out all he can about them, how they work, what happens when they are fired, how the projectile behaves before and after it leaves the muzzle, and why.

As this inquiring attitude of mind does not seem to be encouraged by the military authorities,[1]—it may be on the grounds that "too much knowledge is a dangerous thing"—the engineer will find the greatest difficulty in getting a clear scientific statement of the facts that will satisfy his logical mind, and accord with his knowledge of dynamics and physical laws generally.

This information undoubtedly exists somewhere, and it must have been built up on sound scientific principles, as otherwise the almost incredible accuracy of modern long-range guns could never have been achieved. It cannot be a question of secrecy that makes this information so difficult to unearth—at least so far as the Service rifle is concerned, the fundamental principles and leading characteristics of which must have been the common knowledge of all military Powers for decades.

What published information is available is so cluttered up with loose, if not totally incorrect, statements, guesswork, and reasons that do not accord with scientific principles, that one has the greatest difficulty in sorting out the true facts. Having endeavoured to sift the chaff of hocus-pocus from the wheat of truth on the subject, I give below what I believe to be a few of the pure wheat grains. These will refer mainly to the modern Service rifle.

Let us start with the cartridge, which contains the bullet, the explosive or propellant charge, and the detonator cap for igniting the charge. The detonator contains a very small amount of sensitive chemical compound,[2] which explodes when suddenly compressed by a sharp blow, such as is given by the firing pin of the rifle when the trigger is released. The main explosive charge in the cartridge cannot by itself be exploded by impact. It must be ignited. Britain uses cordite[3] for the explosive charge, but America, Germany, and most other countries have adopted a straight nitro-cellulose explosive. It is obvious that for consistent shooting the quantity of the charge, the physical size and shape of the grains, and its quality must be controlled within very fine limits. This also applies in lesser degree to the detonating compound. Further, these materials must be absolutely stable, so that no appreciable change in their properties will take place over long periods of time. Sealing against moisture is also important, particularly in the case of the detonator compound.

The cartridge case is made of a high-grade solid-drawn brass tube closed at one end, and decreasing in hardness from the base to the mouth. This question of hardness is very important, as the case must not be too hard—to avoid the risk of splitting—and, on the other hand, it must be hard enough to allow of it being easily withdrawn from the chamber after being subjected to the very high pressure of the explosion (about 20 tons per square inch). At the blind end some means of gripping the case must be provided for withdrawing it from the chamber. This may take the form of a small projecting flange, as in the British Service cartridge, or a square-shouldered groove may be machined in the case close to the base—this is the type used by most of the other Powers. These two types are known respectively as "rim" cartridges and "rimless" cartridges. The great advantage of the "rimless" cartridge is that, when a number are assembled in a magazine or feed chamber, they lie practically parallel with one another, and can be fed out smoothly under automatic action without any risk of a projecting flange catching on another flange or on some part of the mechanism.

Cartridges for small-bore (0·22in. bore) rifle ammunition are usually of the rim type, and are made dead flat on the end of the base, the detonating compound being located round the inner recess of the rim. When fired, the firing pin hits the rim (not the centre of the base), and so compresses the detonating compound between the folds of metal forming the flange. Such cartridges are known as "rim fire" cartridges. The larger-bore Service cartridges, whether of the "rim" or "rimless" types, have a central recess in the outside of the base for receiving the detonating compound. This recess is covered over by a small copper cup pressed into place, one or more small flame holes in the base of the cartridge body providing communication with the propellant charge inside the case. Such cartridges are fired by the firing pin hitting the centre of the base, and are known as "centre fire."

The modern bullet is of cylindrical form, with a pointed nose. Streamline bullets—*i.e.*, tapered at the rear end also, but to a lesser degree than at the nose—have been experimented with, because of their obvious advantages in flight, but their concomitant disadvantages seem so far to have precluded their coming into general use. They are, however, used, apparently with success, by the French and Swiss armies and to some extent in the U.S.A. The solid lead alloy bullet used in low-velocity weapons would be useless in the modern high-velocity rifle, as, apart from considerations of penetration, the comparatively soft alloy would be incapable of following the helical rifling grooves cut on the inside surface of the bore. In engineering parlance, the bullet would simply "strip" or "overhaul."

With the exception of the solid bullet of copper-zinc alloy used by the French, the modern rifle bullet is of the "compound" type, *i.e.*, a hard solid-drawn jacket, usually of cupro-nickel alloy, is filled with a plug of lead, except for that part right at the nose, which may be filled with aluminium or fibre, so as to throw the centre of gravity of the bullet towards the rear end. As will be shown later, this rearward position of the centre of gravity has an important bearing on keeping the bullet pointing tangential to its curved trajectory during flight. The cupro-nickel jacket is folded or spun over at the base to retain the lead plug. Further, a canelure (*i.e.*, ring recess) is made in the jacket near the base into which the mouth of the cartridge is crimped for retention of the bullet and for sealing of the charge.

The following table gives an interesting comparison between the calibre, weight, and muzzle velocity of the British Service bullet and those of some other nations:—

| | | Diameter of bore of rifle, inches. | Weight of bullet. Grns. | Weight of bullet. Oz. | Muzzle velocity, ft. per sec. | Excess of bullet diam. over diam. of bore, inch. | Maximum chamber pressure tons per sq.in |
|---|---|---|---|---|---|---|---|
| | *Great Britain (S.M.L.E.) | 0·303 | 174 | 0·398 | 2440 | 0·009 | 19·5 |
| Highest velocity | Germany | 0·311 | 154·2 | 0·353 | 2882 | 0·012 | 17·5 |
| Largest bore | France | 0·315 | 197·6 | 0·452 | 2380 | 0·012 | 17·75 |
| | U.S.A. | 0·300 | 150 | 0·343 | 2600 | 0·0085 | 19·78 |
| | †U.S.A., Model '17 | 0·300 | 150 | 0·343 | 2700 | — | 22·75 |
| Smallest bore | Italy | 0·256‡ | 161·8 | 0·370 | — | 0·011 | — |
| Largest bore<br>Heaviest bullet<br>Lowest velocity | Austria | 0·315 | 244 | 0·558 | 2034 | 0·008 | 19·7 |
| Smallest bore<br>Lightest bullet | Japan | 0·256‡ | 139 | 0·318 | 2500 | 0·006 | — |

* The figures for the Ross rifle are practically identical with those given for Great Britain.

† This is the rifle with which many of the Home Guard are familiar, but the ammunition now supplied for use with it has a much heavier bullet, viz., about 173 grains instead of 150 grains. Furthermore the bullet is now streamlined—or "boat-tailed" as the Americans call it—whereas the old 150-grain bullet was square ended. Data for this "boat-tailed" bullet are not available, but, as the powder charge apparently remains unaltered, the muzzle velocity is probably in the neighbourhood of 2500ft. per second.

‡ Eight nations in all have adopted this small calibre of 0·256in., with bullets varying in weight from 139 to 161·8 grains.

Some particulars of the British 0·303 "armour-piercing" and "tracer" ammunition will be found in Appendix I.

## RIFLING

All rifle barrels have helical grooves cut in the bore to give the bullet spin. The grooves may be anything from four to six in number, each groove being 0·004in. to 0·007in. deep. The British Service rifle has five grooves, each 0·0065in. deep. The width of the grooves is usually the same as the width of the "lands" (*i.e.*, the projections left by the grooving). The "bore" or "calibre" of a rifle is the diameter measured across the tops of the "lands," and not to the bottoms of the grooves.

Bearing in mind these facts, note the excess of bullet diameter over the bore diameter in the above table. These interferences seem excessive to an engineer, particularly when he learns that the base of the bullet may be expanded or "set up" to the extent of another 0·040in. by the force of the explosion before the bullet reaches the actual commencement of the bore.

Rifle barrels are usually made from what an engineer would call a medium carbon steel. A typical composition is:—

| | Per cent. |
|---|---|
| Carbon | 0·5 to 0·6 |
| Manganese | 0·5 to 0·7 |
| Silicon, not more than | 0·25 |
| Phosphorus and sulphur, not more than | 0·03 each |

The yield point is obviously more important than the ultimate tensile strength. The yield should be not less than 26 tons per square inch, and the steel should show an extension of at least 15 per cent. The elastic limit will usually be somewhere between 15 and 20 tons per square inch.

Stainless steels have been tried in an endeavour to get over barrel corrosion, but they have met with little success, as a composition has not yet been found which will resist corrosion satisfactorily, and at the same time possess the requisite mechanical properties for a satisfactory barrel steel.

Cutting the rifling grooves on the inside of the bore was at one time regarded as a secret operation, but there is nothing secret about it now. The grooves are cut one at a time with very light cuts of about 0·001in. at a time. The Service rifles of all nations, with three exceptions, have four rifling grooves; Britain uses five grooves, Denmark and Japan six. Britain and France have left-handed rifling; all the other nations use right-handed rifling. The rate of spiralling may be anything from one turn in 7¾in. to one turn in 10½in. of length; Britain uses one turn in 10in., Germany one in 9½in. Unlike any other rifle, the spiralling of the Italian Service rifle (Mannlicher-Carcano) varies gradually from one turn in 19½in. at the breech to one in 8½in. at the muzzle. (The maximum interference between the cupro-nickel jacketed bullet and the bore is in this case 0·011in.) Would some brilliant engineer please put forward a theory to justify this design of rifling? One can only assume that the originator of the idea had in mind giving the bullet a more gradual increase in rotational motion than is given by rifling of uniform pitch. Mechanically, however, the idea seems entirely unsound.

It is to be noted that the British Service bullet leaves the muzzle with a rotational speed of 175,680 r.p.m., whilst the German bullet leaves with a speed of 218,425 r.p.m.

In the most recent issue of a voluminous Government publication on smallarms, there appears this statement: "The left-hand rifling was originally adopted to compensate for the drift of the bullet due to the rotation of the earth in the northern hemisphere." ("Drift" means the gradual swerving of a bullet to the left when left-handed rifling is used or to the right when right-handed rifling is used.)

Let us consider Fig. 1, which represents the earth as seen from a point vertically above the North Pole. The rotation will be as indicated by the arrows.

Imagine a super gun at the North Pole N to be

[1] In fairness it should be stated that there are definite indications that this attitude of mind is being abandoned, and recruits are now being encouraged to think for themselves.

[2] A compound commonly used contains fulminate of mercury, potassium chlorate, sulphide of antimony and sulphur. It is the products of combustion of the detonating compound (particularly the potassium chlorate and the sulphur in it), and not of the propelling charge, which causes fouling in the barrel of a rifle. The Americans use a compound which is claimed to be free from this disadvantage.

[3] A mixture of nitro-cellulose (gun cotton) and nitro-glycerine.

aimed at a point A on the equator. By the time the projectile reaches the equator the target will have moved from A to $A^1$, hence the projectile will hit to the right of the target.

Again, imagine the gun to be placed at B on the equator and to be aimed at the North Pole. The projectile will leave the gun with a velocity compounded of its muzzle velocity along B N and a velocity B C at right angles due to the rotation of the earth. It will therefore move along some such line as B N, and again it will hit to the right of the target.

Hence we see that, so far as the northern hemisphere is concerned, the earth's rotation will tend to make a projectile hit to the right of a target, whether it is fired due north or due south; moreover, a little consideration will show that for practical gun ranges the effect will vary from zero at the equator to a maximum when the target is at the North Pole. In other words, for due north or due south firing the magnitude of the effect will vary with latitude. Further, when the direction of fire is varied from due north or due south, the effect will become less in accordance with the cosine law until it becomes zero when firing due east or due west. Again, the effect reverses in direction when we pass from the northern to the southern hemisphere.

In the case of the rifle, which has an extreme range of only 2 to 2½ miles, the effect, even at its

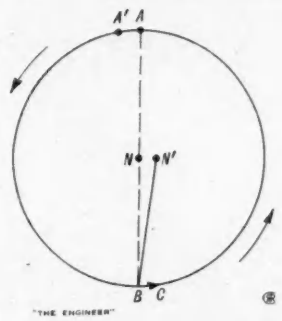


FIG. 1—EFFECT OF EARTH'S ROTATION

maximum, is negligible.[4] Even if the effect could not be neglected, it would obviously be impossible to correct for it by means of "drift," which is the same for both hemispheres and does not vary either with latitude or direction.

The Government publication above referred to goes on to say: "Left-hand rifling also has the effect of twisting the butt of the rifle away from the firer's cheek instead of against it." After the previous statement the engineer feels at once that here may be a sound reason for the adoption of left-hand rifling. But when he inquires of riflemen who have had extensive experience with right-hand rifled guns, as well as with those having left-hand rifling, he is disappointed to find that they definitely assure him they have never noticed the slightest difference between such rifles in this respect. Further, they will tell him that when firing a revolver with extended arm—when the effect should be much more pronounced than in the case of a rifle—they have never been able to detect any rotational kick.

Forgetting this practical evidence for a moment, let us examine the dynamics of the problem. When firing a rifle a right-handed man will rest his right cheek firmly against the butt, and if the rotational kick, resulting from giving the bullet its spin, were to intensify the pressure on the cheek, there would seem to be a possibility of bruising the firer's cheek. Assume that the bullet is given left-handed spin, as in the British Service rifle, *i.e.*, counter-clockwise spin as viewed by the firer. The reaction on the rifle must in consequence be clockwise, and since the butt is always below the axis of the barrel this would seem to indicate that the butt will be twisted against the face of the firer, and not away from it, as one would wish.[5] But we have overlooked the fact that the butt is held against the shoulder at a mean point lower than that at which it bears against the cheek; hence if the butt is held rigidly enough in a sideways direction, the whole rifle will tend to pivot about this low point of contact with the shoulder, and may throw the rifle away from the firer's cheek. What actually happens, at the cheek, seems therefore problematical, and dependent on the degree of restriction placed on any sideways movement of the butt.

The kinetic energy of rotation stored up in a British Service rifle bullet when it leaves the muzzle is about 10 foot-pounds. (Note that this is negligible compared with the kinetic energy of translation, viz., 2298 foot-pounds.) As the bullet takes 0·0012 of a second to traverse the barrel, the average torque to accelerate it rotationally is slightly less than 1 pound-foot.

### LENGTH AND STRENGTH OF BARREL

The length of the barrel of a Service rifle, measured from the rear of the cartridge to the muzzle, varies from 23·2in. (Czech) to 32·9in. (Denmark); Great Britain S.M.L.E., 25·19in.; Germany, 29·15in.

All other things being equal, the longer the barrel within reason the higher will be the muzzle velocity of the bullet and the greater the accuracy. Considerations of ease of handling, however, make it desirable to keep the rifle as short as possible; hence, a compromise has to be made.

The British Service rifle originally had a barrel 30·19in. long, which made it quite unsuitable for cavalrymen, who were therefore equipped with short carbines. To secure the advantages of a common weapon for cavalry and infantry, the long magazine Lee Enfield (L.M.L.E.) rifle had 5in. lopped off the barrel to produce the present short magazine Lee Enfield (S.M.L.E.) Service rifle.

It has been established fairly accurately by experiment that shortening a rifle barrel by 10 per cent. reduces the muzzle velocity by 1·4 per cent.

Barrels are usually tapered on the outside from the breech to the muzzle, sometimes gradually, sometimes in steps. The thickness of the barrel wall in the region of the breech depends on the maximum chamber pressure and the physical properties of the steel used. It has to be borne in mind that the normal maximum chamber pressure, ranging usually from 17·5 to 22·5 tons per square inch in Service rifles,[6] will be exceeded by about 25 per cent. during "proof testing," to which all rifles are subjected. Service rifles have usually a thickness of wall at the breech slightly greater than the bore.

### INTERNAL BALLISTICS

We need not dwell on what takes place as the bullet is accelerated in its passage along the barrel by the explosion of the charge, except to note the

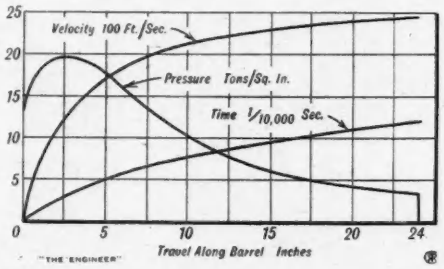


FIG. 2—PRESSURE AND BULLET VELOCITY IN RIFLE BARREL

typical curves of pressure, velocity, and time for a S.M.L.E. rifle with standard Service ammunition, *i.e.*, Mk.VII (see Fig. 2).

It will be noted that the bullet takes 1·2 thousandths of a second to traverse the length of the barrel. The pressure reaches a maximum of 19·5 tons per square inch when the bullet has travelled about 2½in. along the barrel; thereafter the pressure falls off to about 3½ tons per square inch at the muzzle. The velocity rises rapidly at first, then more gradually until at the muzzle it attains a value of 2440ft. per second, or 27·7 miles a minute. The muzzle velocity of the German Service bullet is 18 per cent. higher than this, viz., 2880ft. per second, but its weight is 11½ per cent. less.

High-velocity big game rifles, of calibres of the order of Service rifles, may have muzzle velocities as high as 3500ft. per second, whilst an American rifle of 0·22in. calibre has a muzzle velocity of 4100ft. per second. With these high velocities, however, the accurate shooting life of the barrel is only a fraction of the 4000 to 5000 rounds usually given by the Service rifle.

### JUMP

The explosion of the charge in a rifle sets up a "whipping" vibration in the barrel, as shown exaggerated in Fig. 3. The result is that the bullet leaves along the line M B instead of along A A—the axis of the rifle before firing. The angle $\theta$ may be as much as 10 min., or enough to throw the bullet out 10½in. at 100 yards. Fortunately, with a given rifle and ammunition the direction and magnitude of this angle is practically constant, and can therefore be allowed for in the sighting of the rifle. This angle or rather its projection on a vertical plane through the barrel axis is known as the "jump" of the rifle and may be positive (*i.e.*, upwards) or negative (downwards), depending on whether the muzzle portion of the barrel happens to be whipping upwards or downwards at the instant the bullet leaves. It is fairly obvious that if the barrel is not free in the stock or if a bayonet is fixed to the end of it, or if the barrel is rested on some rigid support, or, again, if the ammunition (charge or bullet) is changed, changes in the nature or magnitude of the vibration will certainly result, with a consequent alteration in the "jump." This is why in rifle shooting one is warned to see that the rifle barrel is free in the stock and that it is not resting on a support. If a support is available, the left wrist only may be

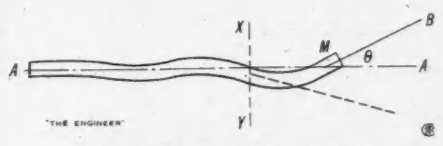


FIG. 3—"WHIPPING" VIBRATION

rested on it, as this will not appreciably affect the barrel vibration.

It is obvious that if a portion of the barrel were sawn off, say, across X Y, a positive "jump" might be converted into a negative jump. This is exactly what happened when the long Lee Enfield rifle was shortened by 5in. to give the short Lee Enfield model. The change in "jump" was from 7 min. positive to 4½ min. negative—a very substantial change.

It should be pointed out that "jump" has nothing whatever to do with the sudden movement of the rifle due to recoil, which may be observed or felt, at the instant of firing. If the rifle is held correctly, this movement will be precisely along the axis of the gun, and should not exceed $\frac{1}{16}$in.; hence it cannot affect the flight of the bullet.

### EXTERNAL BALLISTICS

Now let us examine what happens after the bullet leaves the muzzle of the rifle. Again we

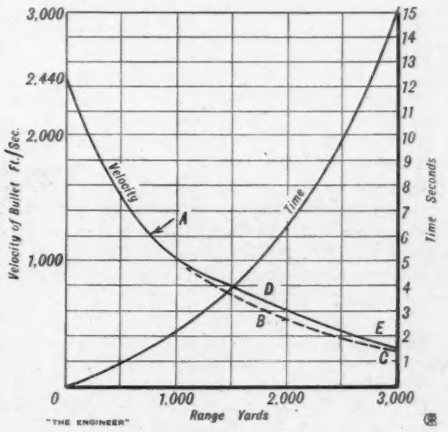


FIG. 4—VELOCITY OF BULLET IN FLIGHT

shall take the S.M.L.E. rifle with standard (Mk. VII) ammunition, as extensive range tests with this combination have been carried out at Hythe, and the results published as a "Range Table from Hythe Firings."

Fig. 4 has been plotted from these results. The velocity of the bullet and the time which elapses from the instant it leaves the muzzle of the rifle have been plotted against the horizontal distance travelled (*i.e.*, the range) in yards. The bullet on leaving the muzzle with a velocity of 2440ft. per second immediately begins to lose speed rapidly, following an approximately smooth curve

[4] In the case of long-range naval or land guns the effect of the earth's rotation cannot be neglected. Cranz, the eminent authority on ballistics, states that a 12in. gun with a muzzle velocity of 2500ft. per second, fired due north in a latitude of 54 deg. N, with an elevation of 40 deg., giving a range of 20·5 miles, deviated 160 yards to the right in that distance, due to the earth's rotation.

[5] The assumption made here that the rotational kick takes place about an axis coincident with the axis of the barrel, cannot be strictly correct. The actual axis will be somewhat lower and slightly inclined in an upward direction towards the muzzle.

[6] High-velocity big game rifles may go as high as 35 tons per square inch.

until the point A is reached. One might expect the velocity to continue to follow this smooth curve until the bullet ultimately came to rest at its extreme range. If so, it would follow the dotted curve A B C. But it does not. Some change sets in about the point A, which causes it to follow the full curve A D E. What is the reason for this change? On examination, the point A will be found to coincide roughly with the velocity of sound, viz., 1100ft. per second, or 750 miles per hour. It is well known that the resistance of air to a body passing through it shows a very pronounced increase when the velocity exceeds that of sound. Hence a rifle bullet, when travelling above the velocity of sound in the initial part of its flight, is subject to a very high air resistance, but when its velocity drops below that of sound this resistance is to a large extent relieved, and consequently the speed of the bullet does not then fall off so rapidly. The law connecting air resistance and velocity is a very complex one. It is shown graphically in Fig. 5 for the particular case of a Service bullet. The curve is for still air of

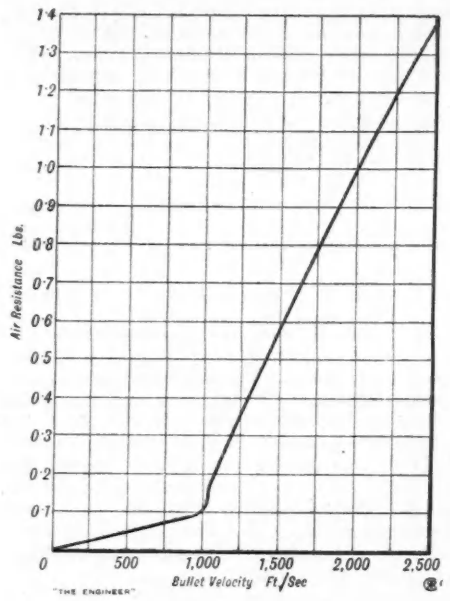


FIG. 5—AIR RESISTANCE OF BULLET

normal density, the bullet having a standard degree of steadiness in flight. Normal air density means Bar. 30in., temperature 60 deg. Fah., and humidity 75 per cent. In the case of high-angle fire, when the bullet travels in rarified air at high altitudes, the resistance is considerably reduced, and the extreme range of the bullet materially increased. This fact was fully exploited by the Germans when they used "Big Bertha" for shelling Paris from a distance of 75 miles. They used an elevation of about 50 deg.

The well-known fact that a rifle fires "high" in rain may not be unconnected with air resistance, as it seems possible that the resistance of a wetted bullet may be less than that of a dry one, giving a flatter trajectory and thus a higher point of impact on the target. Experienced marksmen will tell one that the effect is very much reduced if care is taken to keep the ammunition and the breech of the rifle dry when firing in rain. At the same time they maintain that the light is also a factor. They claim that when it is raining the light is affected in some peculiar manner so that one unconsciously takes a higher aim than normal.[7]

It is a fact that a shot, travelling at more than 1100ft. per second, carries with it in its flight a sharp cracking noise as if it were splitting or breaking a way for itself continuously through the air. This is probably correct. Immediately it drops below 1100ft. per sec., however, the sound waves of its own creating, which previously it was leaving behind it, then begin to travel ahead of it, and in some extraordinary way seem to open up a path for the bullet, and so the resistance of the air to the bullet's motion is reduced. The nasty cracking noise in flight then disappears, and is replaced by a mere hum or hiss. It is said that this change can easily be observed if one walks down the side of a rifle range when long-distance firing is in progress. The change should begin to be noticeable on passing the 1000-yard mark.

[7] According to military authorities, there is no justification for the suggestion put forward. High shots in wet weather are caused by the lubrication of the cartridge case by water and the alteration of the "jump" owing to the alteration of the stresses set up by the case driving straight back on to the bolt face without adhering to the wall of the chamber.—ED., THE E.

The bulk of the noise heard when a rifle is fired is not due to the explosion of the charge, but to the splitting of the air by the bullet after it has left the muzzle. Hence the futility of trying to silence a rifle by means of silencers fixed to the muzzle. Such devices are effective only on low-velocity weapons, such as pistols, where the muzzle velocity is around 600ft. to 700ft. per second, and in consequence the noise from them is due almost wholly to the explosion. Owing to the gap between the cylinder and the barrel, a revolver, though a low-velocity weapon, cannot be effectively silenced by means of a muzzle silencer.

From Fig. 4 one will note that the S.M.L.E. rifle bullet is travelling above the velocity of sound for the first 2 sec. of its flight, covering approximately 1000 yards in that time. Hence if one were to stand about 1000 yards down the range the first thing he would hear would be the crack of the bullet as it passed overhead, prolonged for 2 sec. as the noise from earlier parts of the bullet's flight reached the observer, then at the end of this period a "plop" would be heard, representing the explosion of the charge in the rifle.[8]

It is useful to bear in mind that the British Service bullet travels approximately 600 yards in the first second, 400 yards in the second second, and 300 yards in the third second of its flight. From the curves of Fig. 4 these values will be seen to be approximately correct. More exact figures are 600, 370, and 310 yards. (For the U.S.A. model '17 rifle we have 650, 400, and 320 yards respectively.)

The extreme range of the S.M.L.E. rifle is about 3600 yards, which is given with about 33 deg. elevation (*i.e.*, angle between line of departure of bullet and the horizontal).

For the U.S.A. model '17 rifle an extreme range of about 4400 yards is claimed, at approximately the same elevation.

An interesting fact is that if a Service rifle is fired vertically upwards, the bullet will reach a maximum height of 9150ft., or 3050 yards, or $1\frac{3}{4}$ miles approximately, in $18\frac{3}{4}$ sec. It will take approximately twice this time, or $36\frac{1}{4}$ sec., to fall, and will reach the earth with a velocity of 315ft. per second. This represents a striking energy of 39 foot-pounds, and as "it is considered" that a striking energy of 60 foot-pounds is necessary to put a living target out of action, it would appear that there is less danger from falling bullets fired upwards than might be supposed. The total time of 55 sec. for the up and down trip has been checked by several observers.

*(To be continued)*

[8] According to military authorities "Crack and thump" are well known to all machine gunners, and in locating a hostile gun the range to it may be roughly computed by timing the delay between the two and then listening for the "thump" in an attempt to discover the direction from which it comes without taking any notice of the "crack," which can be very deceptive.—ED. THE E.

# 50,000-kW Turbo-Alternator for Bunnerong

## No. III

*(Continued from page 300, May 9th)*

### THE ALTERNATOR

THE alternator, shown in section in Fig. 17, is designed for a continuous maximum output of 59,000 kVA at 11,000 volts, 3000 r.p.m., and 0·85 power factor. It is noteworthy as being the largest alternator in the British Empire to run at 3000 r.p.m.

An end view of the stator is illustrated in Fig. 18. The stator frame was fabricated from mild steel plates and bars by Messrs. Parsons at their Walkergate Works. The core laminations are of high-silicon steel insulated on both sides with stove enamel. They are punched in segments complete with conductor and ventilation slots and dovetails. The method of punching is so arranged that any irregularity in thickness of the rolled sheets is distributed evenly round the core, thus avoiding the risk of slack core plates. The stampings are assembled with lapped joints and are consolidated under controlled pressure. The stator coils are of the short-pitch type which has the advantages of reducing harmonics in the voltage wave form and of lessening the losses in the machine. The conductors are of helically stranded coreless cable with micanite insulation made with a permanently flexible varnish. This eliminates trouble from differential expansion due to changes of temperature. The ends of the conductors are split and connected to the end windings by Parsons multiple joints. The end windings are of copper strip, arranged in two banks. During the winding, thermo-couples are embedded in the stator so that temperatures may be measured while the machine is in service.

After the stator had been wound and insulated the end windings were impregnated with varnish under pressure. The process consists in lowering the stator into the firm's large impregnating tank, which is 17ft. 3in. in internal diameter by 26ft. deep, and is capable of taking stators weighing up to 150 tons. Here it is dried out under a vacuum as high as 2 mm. to 3 mm. of mercury. One set of end windings is then impregnated with varnish under a pressure of 30 lb. per square inch for several hours. After the tank has been drained of the varnish the stator is dried out and the varnish oxidised by the circulation of warm air. The stator is then reversed in position and a similar cycle of impregnation is applied to the other end windings. This treatment is far more effective than the practice of drying out in the usual way under a moderate vacuum and then spraying the windings with varnish.

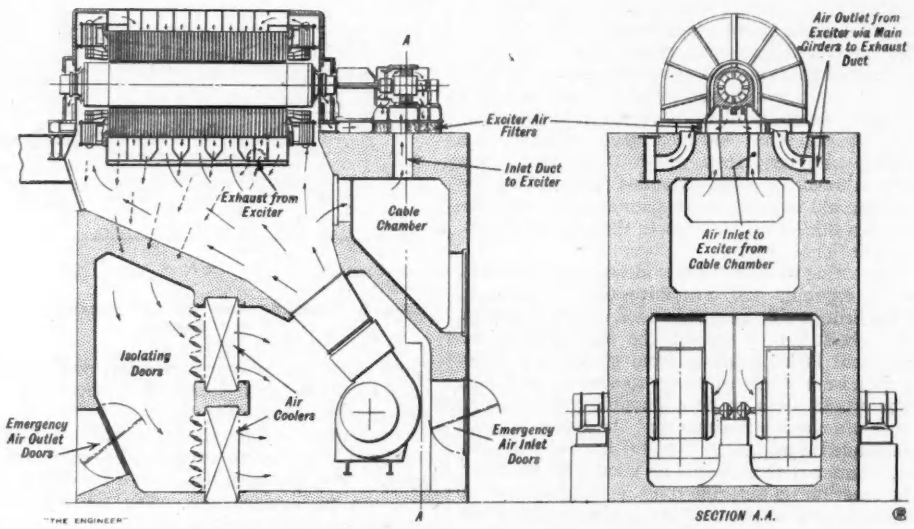


FIG. 17—SECTIONS SHOWING ALTERNATOR VENTILATION

The end shields are made of non-magnetic and non-conducting material which results in an appreciable reduction in eddy current losses. The small weight of these shields is a further advantage, as it allows them to be easily handled and readily removed for the inspection of the alternator.

The rotor is machined from a single forging and is bored through from end to end to enable the interior to be examined and test pieces taken from the core. The winding is of formed copper strip, embedded in radial slots milled in the rotor body. The main insulation of the rotor consists of moulded micanite troughs, the insulation between turns is also of micanite, while the top turns of the end windings are further protected by bakelised troughs. The packing inserted between the end coils of the rotor is machined from specially manufactured bakelised asbestos and is designed to give mechanical support along the axis through each successive corner. In addition, the packings extend from the corners back to the end of the rotor body and the coils cannot distort from their finished position. The axial spaces between coils are also solidly packed with circumferential packings. The caps which support the end windings against centrifugal force are of non-magnetic steel. Damping windings are provided in the slots and the caps are electrically connected to the body by flexible bonding strips. After completion the rotor was dynamically balanced and underwent also a severe overspeed test. The finished rotor is illustrated in Fig. 19.

The exciting current is supplied by a direct-coupled exciter, which in turn is excited by a small

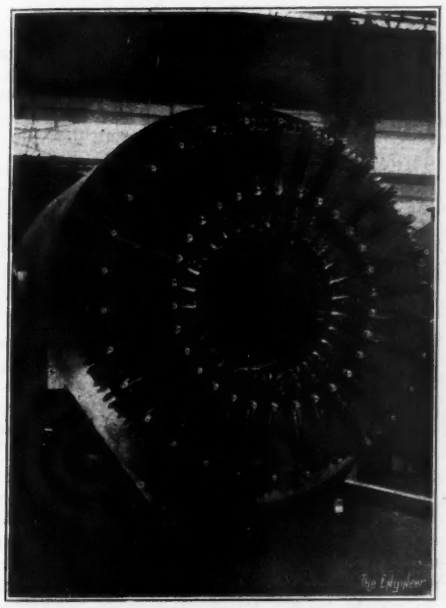

FIG. 18—END VIEW OF STATOR

constant-voltage auxiliary exciter incorporated in the same frame. This ensures the stability of the excitation of the alternator, and improves the performance of the set under transient conditions. The armatures of both exciters are mounted on the same shaft, which is flexibly coupled to the end of the alternator shaft.

The closed ventilation system includes the exciter and slip rings as well as the alternator, so that the whole of the electrical parts are cooled and protected against dust and moisture. The air circulation is maintained by two motor-driven fans housed in the foundation block as shown in Fig. 17, the motors alone being external to the foundations. On loads below three-quarters of the rated capacity of the set one may be shut down, thus maintaining the alternator efficiency at the highest value. Remote lubricating and temperature indicating devices are provided for the fan bearings.

The stator casing is constructed with eleven separate compartments divided by steel plates extending radially to the circumference of the core. Cold air from the fans is delivered along the whole length of the underside of the machine, entering five compartments in parallel, in addition to the spaces enclosed by the end shields. After passing through the core and along the surface of the rotor the ventilating air flows through the radial ducts and leaves by the six intermediate compartments, through which it also flows in parallel. The alternator is, in effect, divided into a number of short elements, each of which has its own supply of cold air and its own exhaust of heated air. The central portion of the machine is therefore cooled just as efficiently as the ends.

For the ventilation of the exciter and slip rings a portion of the cold air from the fans is diverted from the main circuit. The cold air for the exciter is led to a point between the two armatures, where it divides, the major portion flowing axially through the core and windings of the main exciter before passing over the commutator and into a duct in the bed-plate. The remainder of the air cools the auxiliary exciter in the same way. The air is returned to the circuit through filters of the viscous type to remove any trace of dust produced by the brushes before it again circulates through the machine. Small filters of the same type are fitted to clean the air from the slip ring chambers.

A dial thermometer at the side of the alternator shows the temperature of the air leaving the machine and audible warning is given by a Klaxon horn should a predetermined temperature be exceeded. In the case of a failure of the water supply to the air coolers the alternator can be operated with an open air circuit, emergency doors being fitted for this purpose.

The complete machine was erected in the Heaton Works before despatch to Australia, and was subjected to a comprehensive series of tests. Open circuit and short circuit runs were carried out at the maximum rated value of the current, and these indicated that the temperature of the machine in service would be well within the specified limits.

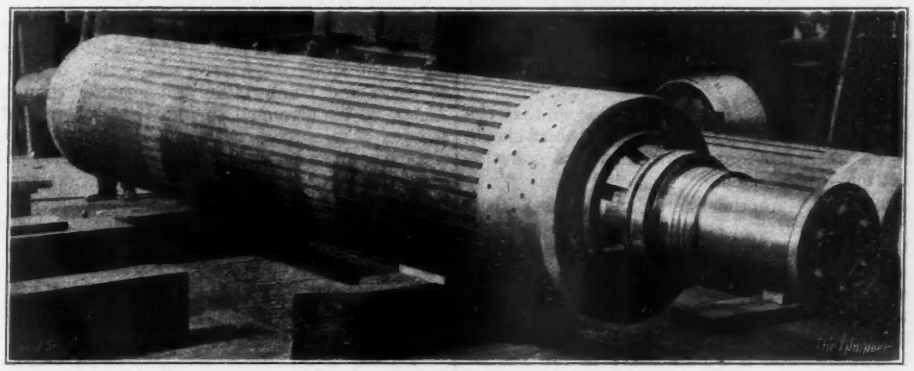

FIG. 19—ROTOR OF ALTERNATOR

Subsequent measurements on site have confirmed this result.

The first of the two sets was put into commission in September, 1939, and has run at the highest output consistent with the operating conditions of the station. The weekly output has recently ranged between 6·5 and 7·25 million units, the average load often being as high as 48,000 kW for several consecutive days.

The second machine has recently been run up to full speed and put on load. Reports indicate that its operation will be as successful as that of the first machine.

# Adventures of an Engineer

By W. J. E. BINNIE

I HAD an adventurous journey home and have written this short account while the incidents are fresh in my mind.

I left Hong Kong by Imperial Airways on Sunday, June 2nd, spent the night at Bangkok and reached Rangoon about twelve o'clock the following day, where I was met by Mr. Mann, the Chief Municipal Engineer, who informed me that he had been unable to secure a passage by Imperial Airways for my return journey, but had obtained one on an Air France aeroplane which was due to leave on June 9th.

I spent a very pleasant week at Rangoon and we started at 6 a.m. on the morning of June 9th, intending to reach Allahabad that night.

The Air France aeroplanes on this route have accommodation for twelve passengers and are faster, but not nearly as comfortable, as the imperial Airways flying boats, which are provided with a bar and kitchenette, so that one can have drinks and hot meals on board and one is allowed to smoke in the after portion of the cabin.

Our aeroplane was called the " City of Beyrout," and we had no English passengers until we reached Calcutta, the only other European being a very interesting Frenchman, Monsieur Lapique, a well-known personality in Indo China. He spoke English very well, unlike most Frenchmen, and as my knowledge of French is scanty he helped me a great deal on the journey. He owned quarries and mines in Indo China, and I discovered that he was supplying limestone to the Green Island Cement Company, who furnished cement for the Gorge dam, which we recently completed for the water supply of Hong Kong and Kowloon.

We reached Calcutta in about three hours and had good weather, except for a thunderstorm near Akyab, on the coast of Burma, which caused the aeroplane to " bump " considerably.

There is no Consul-General for France or Italy in Burma, and therefore the visas permitting one to pass through these territories have to be obtained at Calcutta, where Cooks had sent my passport by a previous aeroplane, the visa for Italy being necessary as our route lay through Libya.

The first shock met me on my arrival at the Dum Dum Aerodrome, where Cook's representative, who met me with the passport, informed me that he had been unable to obtain the Italian visa.

At Calcutta we took up two English passengers who were flying home, a Mrs. Nicholson and Mr. Sasoon, who were in the same boat as myself, so on Cook's advice we shared in the expense of a long cable to the Italian Consul at Beyrout to endeavour to obtain the visas before we entered Libya. It was an expensive and futile cable as events transpired.

The mechanic discovered a defect in one of our three engines, so that we had to stop the night at Calcutta and did not leave until about 11 a.m. the following morning, reaching Karachi the same evening (10th).

*June 11th.*—Owing to the delay at Calcutta, the Commander decided to fly from Karachi to Beyrout on the coast of Syria, but the second shock, the declaration of war by Italy, upset these plans, and we came down at Damascus for the night, refuelling at Bushire and Baghdad on the way, the total distance being about 2100 miles.

*June 12th.*—As Libya was now closed to us we received instructions to fly to Cairo, leaving the aerodrome at 5 a.m. On arrival at Cairo a long consultation took place, and we were informed that the aeroplane was to proceed to Khartoum, but that only Monsieur Lapique and two other passengers would be allowed to proceed, Mrs. Nicholson and myself being told that we had been selected. A Mr. Newman, diamond merchant of Hatton Garden, had joined the aeroplane at Karachi, and it was discovered that he had no visa permitting him to stay in Egypt, whereupon I was told that I must give up my place to him. Mrs. Nicholson then offered to let me go instead of her, as she would probably return to her husband at Calcutta, which offer I gratefully accepted, and, in view of subsequent events, she would have found the rest of the journey intolerable.

We reached Khartoum about 8 p.m., having had nothing to eat since 5 a.m., refuelling at Wadi Halfa, where it was unpleasantly hot.

*June 13th.*—We left Khartoum about 6 a.m. and had intended to refuel at El-Obeid, but on reaching the aerodrome our aeroplane was mistaken for an

Italian and we were fired on, so left without landing and proceeded to Darfur, where it was discovered that one bullet had penetrated the landing "flap" on the starboard wing, missing the petrol tank by a few inches.

That night we reached Fort Lami, which is situated on the River Shari, which runs from the south, discharging into Lake Chad. The distance travelled was about 1300 miles, so we got there early in the afternoon. Fort Lami is an attractive spot and the natives were very friendly, the distribution of a little "baksheesh" enabling me to persuade the local musician to play me an instrument something like a guitar. The night was cool, so I had a good sleep.

*June 14th.*—News had now reached us that the French had thrown up the sponge, the third shock, and we were wondering how that was going to affect our future plans.

*June 15th.*—Another aeroplane coming from S. Africa had reached Fort Lami on June 14th and left before we did on the morning of the 15th for Goa viz Kano (N. Nigeria) and Zinder, in French territory. We reached Zinder (500 miles about 9 a.m., and the other aeroplane landed shortly afterwards, when we made the acquaintance of Mr. Guthrie, who is a missionary in the Belgian Congo, and a Mr. and Mrs. Ashton, who live at Kano, all three being on their way home.

Our aeroplane, the "City of Karachi" developed engine trouble during the flight from Fort Lami, and we were told we should have to spend the night at Zinder, while one of the engines was taken down and attended to.

Zinder is a French military fort about 100 miles north of Kano, and those who have read Wren's novel "Beau Geste" will remember the wonderful account of the defence of the French fort in the Sahara, when the dead were picked up and placed in the embrasures so as to give the impression to the Arabs that the Fort was still well manned. From the description given by Wren it is most probable that this was the fort he had in mind, and it was the one photographed for the film.

The fort had no accommodation for visitors, so we were told to call on a Mr. Bolton, who is the local manager for the N. Nigerian Company, and had a house at Zinder, as he might be able to put us up, but on reaching his office we found he was at Kano, so had to return to the so-called rest-house.

They managed to find us some beds and food, but there were no drinks, and the water of the well was so muddy that it had to be treated with alum before water fit for drinking was produced. The sanitary arrangements were also of the most primitive and objectionable character. There is a small officers' club at the fort, and we were allowed to go there to get drinks, but no ice was forthcoming and the temperature was almost unbearable.

*June 16th.*—An examination of the engine yesterday showed that new rings were required for three of the pistons, and we were told that we should have to stop at Zinder for another day. Our mechanic had to work single-handed in that awful heat; the nose of the aeroplane was under the roof of the shed, so that he got shade, but the temperature was over 120 deg. Fah. He was stripped to the waist and the perspiration streamed off him in rivulets. Nevertheless, he stuck to his job and by sundown everything was O.K. for a start next morning.

*June 17th.*—Our next hop was due north across the Sahara, and we made an early start, reaching an oasis called El Abour about 4 p.m. This is a frequent stopping place for French aeroplanes coming from the south and there was a decent rest-house.

The oasis is watered by an aqueduct which, we were told, was constructed in Roman times, conveying the water from hills to the westward, situated about 40 miles away. This aqueduct was entirely in tunnel in the neighbourhood of El Abour, driven in short lengths, the shafts being about 100 yards apart, and an inclined way led down to the tunnel through which the water flowed crystal clear and cool. The aqueduct terminated in a typical Roman distributing basin, from which channels ran to various date plantations, the entrance to the channels being restricted so as to distribute the water according to the quantity required. Remains of ancient walls were visible, but as they were constructed of dried mud they had crumbled away to such an extent that it was not possible to judge their original magnitude.

*June 18th.*—We made an early start and reached Algiers in time for lunch, putting up at the Aletti Hotel, which is the best hotel there. The aeroplane was to leave for Marseilles the next morning, so Newman and I went to the Consulate, but were advised to stay in Algiers. So we returned our tickets to the Air France office, but they refused to refund the passage money between Algiers and Heston, saying that we must recover it in London. The money would have been very welcome, as we did not know how long we should have to stay at Algiers. Fortunately, I had drawn the remainder of the money from my account at Rangoon and had £50 in English money.

*June 19th.*—Shortly after breakfast we met Guthrie and Mr. and Mrs. Ashton, who were staying at the Hotel Angleterre, which they described as clean and comfortable and cheaper than the Aletti, so we arranged to join them there and I secured a nice room with a balcony overlooking the harbour and a small bathroom for 45f. a day, equivalent to about 5s. We found Algiers cheap, and it cost me about 15s. per diem, including meals, at a little restaurant which was run by a French family, a little girl of ten, who generally acted as our waitress, attending to her duties with great solemnity, and we intended to present her with a box of chocolates when we left, but our ultimate precipitate departure prevented us from doing so.

Our next visit was to the Consulate, where we were promised that our names would be put down and that we should be given preference, if an opportunity arose for getting us on to one of the British ships in the harbour.

Visits to Cooks, the police station—where cables had to be passed and stamped before taking them to the Post Office—and the Post Office, took up most of the day.

We found that we could get better exchange at Cooks than at Barclay's Bank, the latter being very reluctant to exchange and ultimately refused to help us.

*June 20th–26th.*—It would be tedious to detail our movements while at Algiers, as our time was mostly spent in visiting the Consulate, where we went twice a day; Cooks, where the English cashier had a wireless set and gave us the latest English broadcast news, also changing money for us, and in wandering about the town.

Algiers is a really attractive spot and the climate was beautiful after the Sahara, and I would have enjoyed my stay if it had not been for our great anxiety and lack of cash which prevented us from making excursions. We did, however, visit the very beautiful botanical gardens twice and had two drives up to the hills which surround the town, where there are many beautiful villas and gardens and a delightfully situated little hotel located in what had been the Treasury at one time, a good example of Moorish architecture. Our way up to the hills was through a valley called the "Ravine of the Savage Woman," when literally translated.

Guthrie proved to be a very interesting and charming man, who was a good linquist and spoke French fluently, so we were greatly indebted to him for making all arrangements.

We were informed on the 23rd at the Consulate that they hoped to make arrangements for us to leave next day by the "Hermes," a large collier of about 12,000 tons but on the morning of the 24th we saw her leaving the harbour. The fort opened fire on her, first blank, and then a shot across her bows, and she was ignominiously brought back to harbour. It transpired that she was trying to sneak out without a pilot, and has since been interned. Our feelings can well be imagined as the last hope of getting away from Algiers appeared to have vanished and our position was desperate, as Barclay's Bank refused to change any English money and we had not sufficient Algerian money to pay our hotel bills. Cooks, however, came to the rescue, and we were supplied with enough money to carry on for a few days.

Mrs. Ashton was by this time on the verge of complete collapse and was doing her best to persuade her husband to return to Kano, as the French aeroplanes were still flying to the interior of Africa.

The last of the Admiralty staff left this day, burning all their papers, and it looked as if our fate would be internment if we stayed at Algiers.

Two other men had turned up by aeroplane and arranged to stay at our hotel, Mr. Ross, the Resident of the Province of Sokkato, N. Nigeria; and Dr. Menzies, the Government Doctor of that Province.

On June 26th we had decided that our best course was to go to Casa Blanca, in Morocco, and see what luck we had there. I therefore arranged with Cooks to change £20 into Algerian francs, which are good in Morocco, and we went to the Prefecture to get the necessary visas, handing in our passports just before the office closed. We returned to the hotel, when we were informed that a telephone message had been received from the Consulate to go there at once. Guthrie dashed back to the Prefecture and managed to secure our passports, although it was after office hours, and he, Newman and I went to the Consulate.

On arrival there we found that the Captain and Wireless Officer of a small collier called the "Herpert" were enlisting the help of the Consul to obtain additional crew. The captain was in a very difficult position, as the major portion of the crew were Turks and they would do no work and had adopted a threatening attitude, refusing to go any further with the ship. The captain was only too anxious to put them ashore, but the French authorities refused to let them land. There were only three Englishmen aboard, the captain, wireless officer and chief engineer, the non-Turkish portion of the crew being Poles, Greeks and Russians. The captain had determined to go to sea with the seventeen mutinous Turks if he could get together enough Englishmen to keep them in check, and readily assented to our suggestion that we should get hold of Ross and Menzies, so that there would be nine Englishmen, counting a bosun, an invaluable acquisition, that the Consul had managed to find for him.

We had then to make arrangements with the port and military authorities to allow us to leave the harbour, which meant a couple of hours' delay, but consent was finally given and we dashed back to the hotel to collect our luggage and get on board the ship, the wireless officer, an excellent fellow and a very fine specimen of an Englishman, shepherding us. The pilot came on board at the appointed hour to take us out, but when he found out about the mutinous crew who were still on board he refused to go to sea and left the ship to report to the military police, and not long afterwards about a dozen soldiers arrived to look after us during the night.

The collier had just discharged her coal and the Turks had refused to clean the decks, so she was in an indescribably filthy condition. Only one cabin was available, which had been occupied by a gentleman who was indifferent to insect life, and Newman, who had taken possession was soon driven out by a battalion of bugs. I was more fortunate than the others, as the captain asked me to sleep in his cabin on the bridge during the periods when we were in port. Guthrie and I had also purchased deck chairs and air cushions, so that we were better off than the others, who had to "doss" down where they could.

*June 26th.*—We spent all day on board while the captain and wireless officer went on shore to see what could be done with regard to the Turkish crew, and were fortunately able to obtain an assurance from our Consul that he would make himself responsible for them. We were therefore delighted to see the arrival of a guard, who took them off the ship and we anxiously waited for the return of our officers, as normally ships were not allowed to leave the harbour after sunset. Time went on, the sun set, and our captain had not yet returned, so our feelings fell to zero. The pilot and tugs arrived to take us off, but it was not till nearly dark that the captain returned, as he had been delayed with a number of arrangements.

Most fortunately, they allowed us out; the "boom" closed behind us and we entered the Mediterranean and subsequently learnt that we were the last British ship to leave the port of Algiers.

*June 27th.*—We had been joined on the ship by a young man called Lawson, whose people lived in Algeria, and a senior officer in the French Air Force. Immediately after breakfast we were signed on as crew, my job being pantry man to assist the Chinese cook, a cheerful and obliging man. Normally there were four men employed in the galley and pantry and the work was very strenuous. I did all the washing up and laid the table, &c. The pantry was a tiny cubby hole next the boilers and the heat was somewhat trying. No water was laid on the taps and it all had to be fetched by bucket from the well deck, where the only fresh water cock was situated. This meant climbing up a vertical ladder with a bucket of water many times a day, an irksome job, and at the end of the day's work I was thoroughly worn out.

There were normally eight men in the stokehold and only three stokers were left, so that Lawson and the French officer had to shovel coal and trim. The five of them managed, however, to keep up sufficient steam pressure to average 8 knots. Guthrie, Newman, Ross and Menzies kept watch

for submarines, but their first job was to clean up the ship as far as possible.

The chief engineer was a typical Scotchman and a very good sort, who worked like a Trojan, as he was also very shorthanded. He and the wireless officer had meals with us. The Chinaman proved to be an excellent cook, the food was good but the meals were too elaborate for my taste, as it fell to my lot to do all the washing up. We had early coffee at 6 a.m., which meant that I had to be in the pantry at 5.45 a.m., lunch at noon, tea at 3.30, and dinner at 6 p.m., and there was hardly time to sit down in the intervals between washing up after a meal and laying the table for the next.

No alcoholic drinks or cigarettes were obtainable on board and there was no ice so that we had to put up with lukewarm water as a beverage.

*June 29th.*—We took forty-nine hours to reach Gibraltar, arriving there at 9 p.m., with calm weather all the way, which was lucky for us, as the ship was in ballast. We only saw one ship, a big liner called "The Embassy," bringing the Ambassadors, &c., back to Italy, which passed quite close to us, but took no notice of us.

On arrival at Gibraltar we anchored out in the harbour for the night.

*June 30th.*—The captain went ashore to make arrangements for a proper crew and coal to take the ship to England, but we were not allowed to land. As there were no watches to keep my companions kindly did the washing up.

*July 1st.*—We went alongside the coal wharf and coaling went on all day, the ship again getting into a filthy condition. Several French seaplanes arrived, and one of them passed over Spanish territorial water, with the consequence that it was shot down in flames and the entire crew were killed or drowned. This incident occurred quite close to our ship.

*July 2nd.*—We were allowed on shore, and Ross, Menzies and I went to see the Colonial Secretary, Colonel Beattie, who was very kind and informed us that the P. and O. "Viceroy of India" was now in harbour to take off a number of soldiers and refugees and that he would endeavour to get us transferred to that ship.

On this day we saw the Fleet leaving the harbour to take part in the Battle of Oran.

*July 3rd.*—The captain and wireless officer went ashore and shortly afterwards a naval picket boat came alongside to inform us that we should be transferred to the "Viceroy of India," and we were to get our things together so as to be able to leave at a moment's notice. It was not, however, till after tea that the picket boat came to fetch us, and we were beginning to fear that we had been forgotten.

The "Viceroy" had collected 1000 officers and soldiers, Czechs and Poles, and 500 refugees in addition to her normal complement of passengers and crew so that the congestion can well be imagined, and, of course, there were no cabins for us.

Mr. Purvis, the Director of Public Works at Hong Kong, had left by the "Viceroy of India" a week after my arrival there, and he was one of the first whom I met when I got aboard. He was most kind and insisted that I should share his single-berth cabin and take his bunk while he slept on the floor. The others were not so fortunate and had to sleep where they could in the music room.

The organisation of the P. and O was excellent. Everyone was handed a printed card indicating the time when he would be fed in the dining saloon, there being three sittings for each meal, and the food was quite adequate and rapidly served.

We sailed at 8 p.m. with a destroyer as escort, which accompanied us for about half the journey, being relieved by another destroyer, which brought us into Plymouth early on the morning of July 7th.

The soldiers were the first to leave the ship, after which a delay took place owing to an air raid. We saw a column of dust caused by the explosion of the bombs which fell quite close to the gasworks, and afterwards learned that several people had been killed.

The passengers left in the afternoon, but we refugees had to spend the night on board and had breakfast at 6.30 a.m. the next morning, but did not leave the ship until about 9.30 a.m. owing to another air raid.

I finally caught the 12.30 train and arrived in London at 5.30 p.m., feeling very thankful for my good luck in getting home again.

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MORE WORK FOR THE B.S.I.—The British Standards Institution is to prepare and issue a series of technical handbooks on British industrial practice in Spanish and Turkish.

## American Engineering News

### Drainage of Deep Mines

As mines get deeper or spread laterally into water-bearing areas the cost of pumping water to enable mining operations to proceed becomes a serious factor in the cost of production. This situation is a serious problem in the coal industry of Pennsylvania, which produces 95 per cent. of the American anthracite including semi-anthracite. At present it is necessary to pump about 33 tons of water for each ton of coal produced. The most serious difficulty is that abandoned workings have been flooded and the water encroaches steadily on present workings, with the threat of destroying vast reserve areas. Thus mines in operation have to pump not only the water normally met with, but also the water flowing from abandoned mines. This condition also makes it difficult and dangerous to sink to deeper levels. In one of the anthracite districts the problem has been solved in part by driving tunnels at such a level as to tap the flooded workings. The Jeddo tunnels, 8ft. wide and 7ft. high, have an average flow of 11,030 gallons per minute, and a maximum of 22,190 gallons. Other mining districts are considering this system, while still others are reducing surface infiltration by improving the channels of rivers and streams to prevent overflows and flooding. To protect the industry it may be necessary for the State of Pennsylvania or the Federal Government to come to the assistance of the mineowners. The same hydraulic problem is encountered in some of the gold mines of Colorado, and under a co-operative plan a 6-mile tunnel is being driven in hard granite to reduce the cost of pumping and also to enable the shafts and workings to be continued at greater depths. Branch tunnels will lead to various mines or properties.

### American Building Developments

Defence preparations are having a marked influence in the building industry of the United States, owing to the programme for high-speed construction of aeroplane hangars, munitions factories, and vast housing accommodations for Army camps and the innumerable new factories. This condition developed rapidly during the second half of 1940 and promised extreme activity for 1941. In spite of much talk and some experimentation, multiple construction or mass construction for dwellings has not made material advance, but for one of the Federal projects for housing munitions workmen it has been proposed to use a number of designs of commercial prefabricated houses. Hangars generally follow conventional designs, with steel roof trusses of either the arch or rectangular types. An experiment has been made, however, with roofs of thin concrete arch type, following the general design of a structure having such arches of 133ft. span. Some aeroplane manufacturing plants of windowless types have been built but owing to certain advantages of controlled lighting and ventilation rather than to "black-out" conditions and war risks. Timber roof trusses put together with "connectors" as well as bolts have been used on some of the factory buildings for defence work. A novelty in industrial building design is a tractor factory having welded cellular units for roof and walls, so that no roof trusses or wall columns are used. Interior columns are pipes having gusset plate connections welded to the roof units. Air conditioning applied to existing structures often results in unsightly appearance of the duots, but when applied to new buildings the ducts are sometimes combined with new designs of steel framing. Bomb-proof construction is considered only in an academic way.

### Harbour Works at Mobile

The shipping business of the port of Mobile, on the Gulf coast, has made it necessary to extend the berthing and cargo handling facilities at the State docks. As in the existing works, a dock or slip extends diagonally from the Mobile River and has on each side a reinforced concrete wharf, with warehouses and transit sheds on solid embankment, and railway tracks and yards and a highway in the rear. The wharf is 1250ft. long and its transit shed is 1000ft. long and 135ft. wide. Concrete piles, 16in. square and 45ft. to 60ft. long, are capped by concrete beams, upon which are eight lines of longitudinal girders carrying a deck slab 50ft. wide. Three railway tracks have their rails laid in recesses in the slab and secured by clips and nuts on anchor bolts embedded in the girders. Along the rear row of piles is a curtain of creosoted wood sheet piling to retain the upper part of the filling or embankment, while under the edge of the wharf is a row of creosoted fender piles. The filling is of clean sand, as being much more economical than to support the building on piles. The steel frame shed is a one-storey structure with a clear inside width of 120ft. On the landward side the steel roof extends 14ft. to cover an outside platform at floor level and 3ft. above the rails of a railway track alongside. Columns in the front wall are supported on the wharf; those at the centre and in the rear wall have concrete footings on groups of wood piles. The sides are of corrugated steel sheeting above low concrete walls, with frequent openings having rolling steel doors. A complete sprinkler system provides fire protection. As this port is in the Gulf hurricane area, the wharf deck is put 3ft. above the highest flood record, and is provided with vents in case a storm tide should overflow the deck. The transit shed is also designed to resist winds of high velocity.

### Æsthetics in Engineering

This perennial subject has bloomed again in the United States, with special reference to buildings and public structures of waterworks, sewerage plants and hydro-electric power stations. For proper consideration of æsthetics in engineering design the responsibility may be divided between the engineer himself, his employer or supervisor and his college professor or educator. On his part, the educator should impress upon his students the desirability of considering the appearance of structures and the relation of their appearance to the surrounding and adjacent structures. Many engineering structures are bare and ugly, merely because the æsthetic aspect of design has been neglected. In recent years, however, there has been marked improvement in this direction. One line of improvement has been in the building of sewage treatment plants, the purpose being to modify general public disapproval of such plants. With buildings and grounds of attractive appearance, and with careful suppression of objectionable odours, such plants may and do receive public appreciation. Buildings and tanks of waterworks plants are in the same category, and in many cases the public are welcome and invited visitors. Consulting engineers and heads of engineering departments in public service organisations or private concerns are in a position to stress the importance of attractive appearance of structures in dealing with their own staff or with the officers of companies or public departments. But the individual engineer has a large share of the responsibility for due consideration of the æsthetic factor in design, and he may meet this responsibility by undertaking some study of architecture, city planning and landscaping, as well as the economics of attractive design in comparison with bald design of walls and roof as shelter from the weather.

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## Production of War Material

IN its twelfth report, issued a few days ago, the Select Committee on National Expenditure says that up to date it has had little cause to complain of the manner in which Departments have met its criticisms and recommendations in so far as these fell strictly within the sphere of a single Department. At what may be called the inter-departmental level, however, it has not had the same happy experience. In part this arises from that close concentration upon individual problems which is produced by the traditional autonomy of Departments, and in part from the failure of information and criticisms to percolate from those who are actually carrying out the work to those who are directing and controlling it at the centre. Highly-placed witnesses have made statements which suggest either that they are unaware of some of the relevant facts and considerations, or that they have not fully appreciated their practical significance. It is sometimes difficult to escape the impression that they work in an atmosphere which is too strongly buffered from outside impacts. The causes of this complaint, which is by no means peculiar to the supply and production Departments, are many and various. In its examination of expenditure the Committee has had its attention drawn, both through official and unofficial sources, to a great number of practical difficulties in the way of achieving the maximum of economy and efficiency. Many of these have been revealed as the result of the frequent visits made by Sub-Committees to factories, camps, aerodrome sites, shipbuilding yards, local civil defence organisations, various departmental out-stations and other institutions. These matters have been followed up in the ordinary course by the examination of the appropriate departmental officials; and on the facts so ascertained the Committee has founded its conclusions. During this process of examination, difficulties, which had sometimes not been recognised by the central department, must become apparent to the witness; and the Committee is glad to acknowledge that in many cases it has learnt of prompt remedial action being taken. Departments have truthfully stated that they encourage, both within and without the Department, suggestions leading to increased economy and efficiency; but the cumbrous machinery through which these suggestions apparently have to pass before reaching a level at which decisive action can be taken often has a sharply deterrent effect upon those who might otherwise put them forward. The Committee has had examples of this brought to its notice, as well as of cases where sensible suggestions have been turned down as a matter of routine apparently before they reached an officer who was sufficiently informed to appreciate them. This latter state of affairs leads to the more vigorous or influential complainants taking undesirable short cuts to overcome their personal difficulties, which merely increase the difficulties of others and cause not only unnecessary friction, but probably a reduction in general efficiency.

# The Engineer

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## THE YOUNG OFFENDER

IT may be taken that something approaching 99 per cent. of the labour engaged upon war work is doing its best for its country. The remaining 1 per cent. gives some cause for anxiety, not because of its actual volume, but because it is sufficient to leaven the whole lump. It is composed nearly entirely of young men who are guilty of acts far more of thoughtlessness than of malice, though we cannot neglect altogether the antipathy to employers, whomsoever they may be, which is found amongst those who favour and foster class consciousness. Were it desirable to do so, many specific examples of thoughtless recalcitrance could be given. They exist all over the country and every employer is familiar with them. To exaggerate their importance would be to do a grave injustice to the hundreds and thousands of men and women who are giving of their best for their country in its need. At the same time, it would be dangerous to shut our eyes altogether to disturbing events and to make no effort to cure them. That they can be cured is beyond doubt, but the cure calls for courage; in the first place from the steady workmen, in the second from the employers, and in the third from the Government.

A factory is a microcosm of the world. There are in it all sorts and conditions of men and women, and in consequence there are always much divergence of character and many different views. But in an emergency like that which prevails the stable elements are far more numerous than the unstable. Unfortunately, in the works, as in the world, it is the latter who are voluble and upsetting, whilst the others desire to pursue their work in quietness and peace. True it may be that in ordinary times it is the noisy minority that gets reforms carried out. But these are not ordinary times and the troubles have nothing to do with reforms. They are the outcome, as we have said, more often than not of mere thoughtlessness coupled with a love of change and adventure, very natural in youth. For example, it has happened on several occasions that young men have absented themselves from their work, forgetting that other workpeople would be held up thereby. A tale, possibly apocryphal but instructive nevertheless, about how women dealt with a case of that kind might be told. It showed courage of a very practical and effective kind. That is the point it is desired to make. If only the steady workpeople would take matters into their own hands they could do more than their employers, the trades unions, or the Ministry of Labour to put an end to such practices. A little relish of the unwritten autonomous control that is found in the best schools and universities would do much to check the harmful ebullitions of irresponsible spirits. It must not be forgotten that the power of the employers is greatly curtailed at the present time. Managers are not quite clear what they may do and what they may not do, and in consequence let things go their own way. That is an inevitable result of divided responsibility. Nevertheless, it must be resisted. As long as concessions are granted without resistance, concessions will be demanded. It is the clear duty of employers to make such resistance as they can and when they have reached their limit to invoke the help and direction of higher authority. Indifference only fosters further trouble; firmness at the beginning would end it. The trades unions, too, must play their part. As already indicated, nearly all the friction is made by young men and very rarely involves the principles of trade unionism. The troublesome youths play for their own hands and give sufficient thought neither to the rest of the workpeople nor to the needs of the country. Many of them, it may be suspected, have never considered the results of their actions. Here the unions could do a great deal. With courage they could put a stop to undesirable episodes and activities. They could make the lot of youthful offenders hard, and in doing so they could count on the sympathy and co-operation of the great majority of their more responsible members. Finally, the Ministry of Labour ought to exercise the powers with which it has been entrusted. It is not sufficient that it should organise a great pool of labour. It must see to it that that pool is properly used and that disruptive elements are not permitted to impair its efficiency. For example, it is surely a mistake to permit men whose training and ability in a reserved occupation makes them indispensable to be lured away from it by the temptation which a certain military service holds out to adventurous spirits. The Secretary of State for Air and the Minister for Labour should not pull against each other. To permit, even encourage, expert toolmakers to go a-flying, not only upsets production by removing essential men, but has a disturbing effect in the works by reducing the sense of responsibility of the workpeople, particularly the younger ones.

In a country so saturated with the principles of liberty as this there is always reluctance to use coercion, even when the power to do so has been endorsed by Parliament. Halévy has pointed out that a characteristic of the English is that they make autocratic laws but dislike exercising them. By preference they depend more upon unwritten laws than upon written ones. What might be called the general democratic sense has a greater effect upon the conduct and behaviour of the people than the Statute Book. The spirit of "it isn't done, my boy," is not peculiar to the public school or society; it runs through all ranks and is found in all occupations. That controlling code may wax thin and weak at times, but it is always there. In the works it may be and is a very important factor. The older and more responsible workpeople have a great power and the pity is that too often they fail to exercise it. There should be a better leaven of steady workers amongst shop stewards and in their committees. Again, there is a class of mind, growing perhaps in number, that likes to be ordered about because it believes that inequalities can only be cancelled when all do what they are told—like Germans. Minds of this order do not believe in voluntary service. They are willing to do just so much as Tom, Dick or Harry; but all must be subject to one and the same command. Thus we have two directions in which the control of youthful offenders might be exercised. The first is the influence of the majority of the workers themselves; the second the issue of positive orders and instructions from those authorised to give them. If both these powers are wisely and firmly used there is little doubt that the small fraction of disaffection that remains can be removed.

### Night Bombing

As we have been insistent on the desirability of enlisting engineers in the search of means for countering night bombers and have been critical of the work of the scientists, we wish to be amongst the first to congratulate all those engaged in the research and development of novel apparatus and in its use, upon the recent remarkable successes achieved with its help. The first reaction when evidence of greater success was shown by the returns was that it was due to the skill of selected pilots, an increase in the number of night fighters, and especially favourable weather. But much as those three things must have contributed to the fine results of the past few nights, it seems obvious that our pilots must have been assisted by "other devices" of some kind. Those devices can only be an apparatus of a distinctly scientific kind, upon which the research departments have been busy for many months. The successes already attained raise the liveliest hopes. Manifest though it be that at the moment outstanding results like those of last week can only be attained with exceptionally good night visibility, they justify the faith of the scientists that in the not distant future very good, if not equal, successes will be recorded in far less favourable conditions.

One question inevitably arises when the returns of raiders destroyed are made public. What percentage of the total number of attackers was brought down? No one questions that the enemy in the great raid on London last Saturday was exceptionally numerous. On that occasion at least thirty-three raiders were accounted for, the majority by fighters. On Sunday night, roughly one-third of that number was destroyed. There are no published grounds for saying that the percentage of planes brought down on these two nights was the same, but the Air Ministry is probably in a very good position to make at least a reasonable guess. Our observers are now so expert that there is much likelihood that they know within a fair margin how many planes cross the coast, even at night. It may be asked if there would be any grave objection to making the estimate public. That would give us a ready means of estimating our own progress, and would afford the enemy no information that he did not already possess.

Whilst giving unstinted praise to the scientists for what they have achieved, we express the hope that practical men and engineers of an inventive turn will not give up their search for other means of destroying night bombers, and particularly of means for preventing their approach to a target. Many of the bombers are brought down after they have done their lethal work. Means of preventing them from crossing certain lines are still required, means less costly and more effective than a gun barrage. The remarkable achievement of the new means employed must not lead to any abatement in the search for yet "other devices."

## Literature

*Works Organization and Management.* By E. J. LARKIN. Sir Isaac Pitman and Sons, Ltd., London. 1940. Price 35s. net.

WHEN an endeavour is made to cover so wide a field as that of works organisation and management in the compass of one volume, it must be apparent that the subject cannot be treated in detail, and that some aspects may have to be ignored entirely. The author has handled his matter well, so that both engineer and engineering student will benefit by reading the book carefully, and the latter will find that it enables him to understand and appreciate the main principles and thus to approach its study in an orderly and logical manner.

In a review of this nature it is not possible even to name the different phases that are surveyed, for there are thirty chapters, each dealing with a distinct branch, and conducting the reader in a methodical way from the selection of a site, and the lay-out of the factory, down to the final inspection of the finished articles produced in that factory, followed by an account of store-keeping and a discussion on the important problems incident to sales organisation and tendering.

We should like to allude to some of the features not usually found in works of this sort, and then to comment on some of the more noticeable omissions. The author is to be congratulated on devoting a whole chapter to the Elimination of Waste, a consideration that is too often ignored by the organiser. We fully agree with the necessity for taking steps to throw into relief the many examples of waste that are encountered in the average factory. Mr. Larkin alludes to the leakage of compressed air. He might with advantage have included gas, steam, lighting—indeed, services generally—as well as all consumable stores. An even balance has been maintained by the suggestion that spending sometimes saves, and that ruthless economy may actually be regarded as waste! A firm might appear to be saving by eliminating all advertising, whereas actually this would have a very adverse effect on the prosperity of the concern.

We are also interested in the attention given to the question of apprenticeship, and particularly in the Larkin system of training. We suggest, however, that the author is hardly accurate in averring that only recently has attention been paid to the systematic training of apprentices, for many firms have had excellent schemes in operation for quite a long time. While we agree that "every works should aim to give all its apprentices an equal chance within the limits of the factory," we are not satisfied as to the basis being the normal number of apprentices required in the shop. This ignores entirely the nature of the work, and might lead to a lad having but a short period on highly skilled work and far too long on work of a simple nature. For efficient training time must be governed by the type of work, even at the expense of output. A firm should be prepared to sacrifice something to ensure the best course for its potential staff.

We welcome the prominence given to Estimating, as this function is of paramount importance, the writer correctly saying that it "is unquestionably the work of a specialist"—a man of a high order. But this brings us to a regrettable omission, that of the cost accountant and his department. Cost accounting falls essentially within the province of the works, as distinct from the general accounts branch which has advisedly not been treated in detail. In the well-ordered factory, cost accounting and estimating go hand in hand, the actual costs obtained being usefully tabulated side by side with those estimated. In future editions we suggest that a chapter be devoted to cost accounting.

There is much on which we should like to comment in this interesting and useful book; we should like to have made a case for an ordering level to be determined between the maximum and minimum store figures, and we should like to discuss the type of man advocated for salesman; but our space has gone, and we conclude by citing from the end of a chapter the quotation from G. K. Chesterton: "The cause which is blocking all progress to-day is the subtle scepticism which whispers in a million ears that things are not good enough to be worth improving." The author indicates the road along which improvement is well worth while.

## Letters to the Editor

*(We do not hold ourselves responsible for the opinions of our correspondents.)*

### APPRENTICESHIP

SIR,—I was particularly interested in the article on "Selection and Training of Apprentices" and your editorial dealing with the same matter, which were published in the issue of April 25th. Mr. Russell is quoted as saying that "the importance of a well-trained labour supply is universally recognised," but later he disproves this contention by indicating the haphazard "dangerous procedure" which, in many places, masquerades under the name of training. This matter is of considerable importance to our country, and I contend that it should be receiving a great deal more attention than is evident at the present time.

Many large firms are attempting to solve the problem of adapting apprenticeship to modern industrial conditions and every credit ought to be given to them for the part they are playing in endeavouring to convince others of the necessity of planning in this connection. These firms are, however, shouldering a burden which should be spread over the whole of industry. In spite of much rationalisation, I think it is still safe to say that the smaller firms are responsible for the control of the majority of the apprentices, so it seems obvious that particular attention should be given to the difficulties encountered by these firms in a serious attempt to solve the apprenticeship problem.

Mr. Russell rightly stresses adaptability as being one of the important characteristics to be aimed at in any scheme of training, so I think we must come to the conclusion that many of the smaller firms are in a poor position to cope with this. If all the small firms in an industrial area were to band together and evolve a common apprenticeship scheme then they would undoubtedly be in an even better position than their larger competitors. I would suggest that the apprentices should spend part of their time in a joint training workshop and part in the employer's factory. The training workshop might, very conveniently, be placed in the local technical college, since the nucleus of such a shop in most cases already exists there.

Such a scheme would ensure definite training in all the practical work usually found in the area, and it would also be possible to give every trainee a sound appreciation of the other trades with which he will come into contact. Another important point in favour of such collaboration is that it would enable both theory and practice to be taught in their proper relationship, and this would make for all-round efficiency.

If it is agreed that we would not now be feeling the lack of skilled labour so keenly if more had been done in previous years to encourage the training of apprentices, then surely more ought to be made of the position. A great deal is being done in the matter of emergency training to meet immediate requirements. A national apprenticeship scheme is an urgent necessity. We should not lose sight of the fact that human skill and ingenuity are our most important possession, and we therefore ought not to tolerate a position which allows our young people to spend their most valuable years merely "picking up" a trade.

G. F. JOHNSON.

The Technical College,
Wakefield, Yorks, May 7th.

## Sixty Years Ago

### ELECTRICAL RAILROADS

IN a leading article in our issue of May 20th, 1881, we expressed the opinion that electrical railroads were about to enter the domain of practical engineering. In the summer of 1879 Siemens and Halske had exhibited at Berlin an experimental electrical railway. Similar apparatus had been shown in 1880 at Düsseldorf and Brussels and was now being shown at the Crystal Palace. Siemens and Halske had proposed to the Berlin authorities that an elevated railroad worked on their system should be constructed. The line, 6¼ miles long, would, it was estimated, cost £72,500, with an annual expenditure of £9720 on the basis of 200 trains per day. The line was to provide a clear headroom of 14ft. 6in. above the street level and was to be supported on iron columns about 11 yards apart. One rail was to serve as the conductor and the other as the return. The proposal was rejected partly because the inhabitants along the route objected to having people looking into their first floor windows and partly because the Emperor held that the railway would disfigure "Unter den Linden." A less ambitious scheme for a railway on the ground level running for about 1½ miles between Lichterfelde and the Military Academy was sanctioned and was, we reported, operating satisfactorily. The authorities, however, persisted in classifying it as a one-horse tramway and thereby limited the permissible speed of the trains. We briefly discussed the nature of electric railways as then contemplated and pointed out the great difficulties of obtaining the requisite degree of insulation, particularly in a damp climate such as that of this country. We suggested that, as an alternative to the dynamo and the two-line conductor system, secondary batteries might be used. In that connection we recorded that Monsieur Camille Faure was reported to have succeeded recently in making great improvements in the Plante secondary battery. Discussing the advantages of electrical railroads, we said that they would have a useful application in underground railways. . . . Faure's battery consisted of a cylindrical leaden vessel, 5in. in diameter and 10in. high, containing alternate sheets of metallic lead and minium wrapped in felt and rolled into a spiral kept moist by acidulated water. Four such elements were grouped within a wooden case. One such "box of electricity" had been despatched from Paris to Sir William Thomson for examination and testing and had reached him seventy-two hours after it had been charged in Paris. It was stated to hold energy equivalent to nearly one million foot-pounds and to weigh 75 lb.

## Metallurgical Research in South Africa

THE decision of the Mines Department of the Union of South Africa to carry out the Government's policy for prosecuting the war, and at the same time developing the Union's economic resources, has included attention to the finding and exploitation of base metals. The Department has been urged to do more than survey the country; it has been urged to do something in the way of prospecting.

This decision to stimulate the exploitation of base metals will not only lead to the unearthing of further deposits of base metals, but will also provide the Metallurgical Research Laboratory at the University of the Witwatersrand at Johannesburg with much greater opportunities for conducting researches in respect of certain base metals which South Africa desires to see brought to the stage of commercial exploitation, which is one of the purposes which was in mind when the Laboratory was established. Since the Laboratory was established in 1935–36 it has provided invaluable aid to many who have requested assistance. The Laboratory not only concerns itself with research, but in addition to the elucidation of ore treatment problems, work primarily of value for its scientific interest but which may afford information of considerable value in connection with existing methods of treatment may be undertaken, as, for example, laws governing crushing efficiency, methods governing crushing efficiency, methods of assay, collection of dust, &c.

As illustrating the kind of work undertaken, a few descriptions are given of what has been and is being done.

In the Northern Transvaal large quantities of phosphate-bearing rock occur, on the development of which a large amount of money had been spent, with the result that the operators found it possible to produce, by means of a modern flotation process, a high-grade concentrate in the form of fine powder. However, when tested by the usual "citric soluble" test, it was scarcely soluble, and therefore not generally acceptable. It could apparently be rendered soluble by converting it to superphosphate by the usual sulphuric treatment, but to this course there are obvious objections, and the Laboratory undertook the finding of an alternative and cheaper method to make it widely available to Union farmers.

In the millions of tons of titaniferous iron ore occurring round the Bushveld igneous complex, the Union appears to possess an asset of great potential importance. Notwithstanding that very little use is made of this material elsewhere, it seems that it ought to be possible to utilise its iron content, while the titanium oxide might be extracted and used as a substitute for white lead in paint, and, concurrently, its vanadium oxide content might be turned to account, and some preliminary work has been done on this problem. An investigation has also been made as to the possibility of finding further use for the considerable quantities of chromite found in the same formation, such as the using it for stainless steel and also as a component of refractory brick.

Work of this character obviously needs the provision of a very wide variety of experimental appliances and machinery, as well as the customary analytical and other routine apparatus, such as microscopes and pyrometers. Much of the apparatus has to be designed and constructed specially for the work. Nevertheless, the expenditure involved will be fully justified by the assistance which it is confidently anticipated will be rendered to the mineral industry in the course of time.

# Straining of Water and Sewage

By P. L. BOUCHER, Hons. B.Sc. (Lond.)

### MECHANICAL SEPARATION OF SOLIDS FROM LIQUIDS

PROCESSES for the separation of suspended solids from liquids fall into two classes. The first includes processes, usually conducted on a large scale, in which the liquid is at rest or flowing with extremely low velocity, whilst the solids fall through it under gravity and settle to the bottom of the container. This is sedimentation. In the second class of process the liquid passes through some kind of network of wires or threads, perforated plating, porous membranes, or through porous beds of granular material. The suspended material or certain sizes of the material are mechanically removed. This process may be generally described as filtration. Straining is a special case of filtration, and although it may have as its object either the clarification of the water or the dewatering of the suspended solids, this article is limited to consideration of those processes in which a barred, perforated, or woven medium is used in water treatment and sewage disposal. Thus we are not concerned with the type of straining that takes place through filter paper, nor with any of the similar straining processes familiar in the laboratory, nor with the

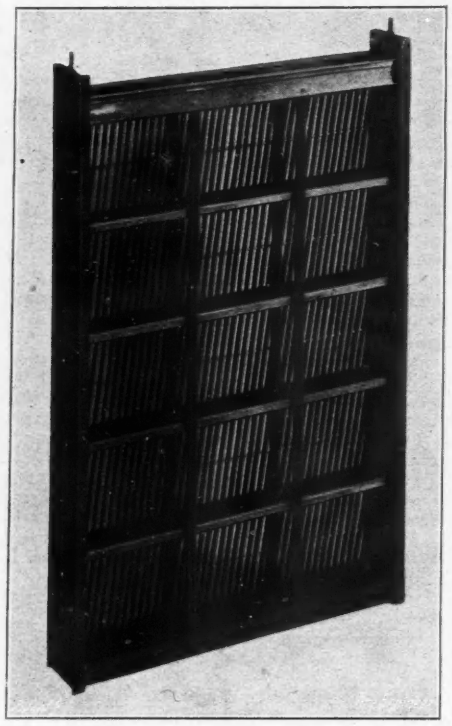

FIG. 1—TRASH RACK FOR HYDRO-ELECTRIC INTAKE

use of sand beds, filter presses, nor with any of the clarification processes in which filter aids and vacuum filters are used.

In practical applications of the straining plant under consideration, three degrees of straining may be defined—coarse, medium, and fine, depending upon the size of the apertures in the straining medium.

### COARSE STRAINING

The coarsest strainers are those used at hydro-electric intakes, in pump suction wells for water and sewage, and on sewage outfalls and similar situations. Such strainers may be of rack construction, with bars at perhaps 3in. pitch. They are used to keep back floating branches, sticks, and other large *débris* which might endanger turbine runners and pump impellers, or block waterways. On sewage outfalls coarse racks retain the larger detritus and minimise the risk of fouling of foreshores. Floating booms can be used advantageously in conjunction with straining racks, the boom excluding all material coming forward on the surface.

In hydro-electric works it is good practice to build inclined trash racks having a slope of 1 to 2 in 6, to facilitate raking. There is no reason why inclined racks should not be generally adopted as they are easier to clear, and if they are to be lifted for clearing, there is less risk of *débris* falling off the racks and being swept into the intake. In some cases provision is made for placing a clear rack before the withdrawal of a blocked rack, but there is always the risk of *débris* from a blocked rack falling off when it is withdrawn. This risk can be practically eliminated by the design of trash rack shown in Fig. 1, which is therefore particularly suited to deeply submerged screens when clearing by raking is difficult or impossible. This trash rack consists of a series of substantially horizontal trash trays and backwardly inclined screen bars arranged in saw tooth form in a frame. Since the screening bars have a backward slope they tend to be self-clearing, whilst the trays retain all the *débris* that falls from the bars. The trash rack is raised and lowered as a complete unit by means of ropes or chains, and gearing mounted on a suitable gantry. This straining device gives at least 50 per cent. greater effective water passage than a flat rack of the same overall dimensions, and, in addition, it is of very rigid construction.

Another type of coarse strainer used in hydro-electric practice is shown by Fig. 2; the straining medium in this case is woven wire, nearly ¼in. diameter, having 2in. square clear openings. A large perforated trash tray is fitted at bottom of the strainer to collect *débris* and hold it when the complete unit is lifted for cleaning.

Fig. 3 illustrates a sewage installation in which the straining medium is manganese-bronze plating perforated with slots having 0·812in. by 0·1875in. clear opening. These particular strainers deal with 14 million gallons per day of crude sewage, after it has passed a coarse bar screen and before it passes to a sea outfall on the West Coast of Scotland. A similar but larger sewage screening installation on the East Coast of Scotland has a mild steel plate straining medium with ¼in. diameter perforations.

Coarse straining generally may be defined to include the use of all types of media from the bar racks and perforated plating described above, down to woven wirecloth having four or less meshes to the inch, with apertures not less than about $\frac{3}{16}$in. The coarsest of these, the bar racks, are often used in conjunction with finer strainers, typical examples being found at condenser cooling water intakes for power stations where screens which may have apertures between $\frac{3}{16}$in. and ¼in. are installed usually downstream of bar screens.

### MEDIUM STRAINING

Medium straining may be defined as the use of woven wirecloth having more than four meshes to the inch up to 40 meshes, with apertures roughly between ⅛in. and $\frac{1}{64}$in. Straining through such meshes will remove the bulk of palpable suspended matter in river waters, industrial effluents, &c., and render them fit for use in many circumstances where the highest standard of clarification is unnecessary. Square mesh and ribbon mesh cloths of plain weave are used. Perforated plating, although it can be obtained with holes within the defined range of sizes, is not usually to be recommended on account of the relatively low

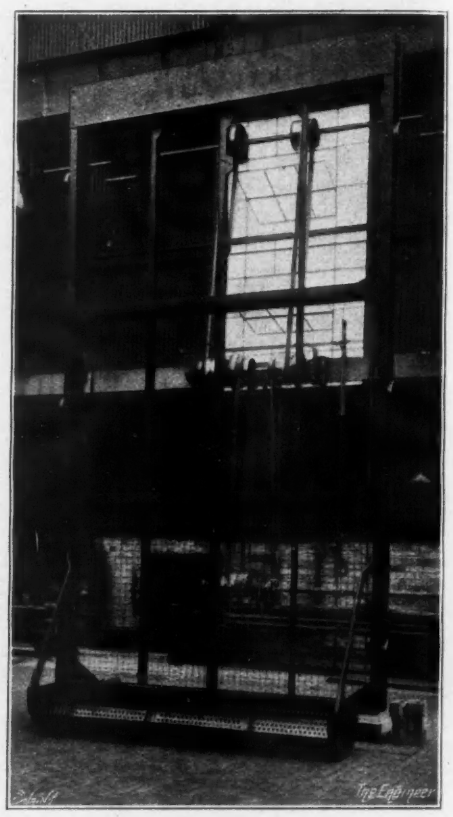

FIG. 2—WIRECLOTH STRAINER WITH TRASH TRAY

percentage of open area compared with that of wire cloth.

Typical examples of square mesh and ribbon mesh wirecloth suitable for medium straining are given by Fig. 4. This material is used on removable strainers for waterworks screening wells, on automatic screening plant, and in enclosed strainers for water mains, such as that illustrated by Fig. 5.

### FINE STRAINING

Fine straining may be defined as the use of

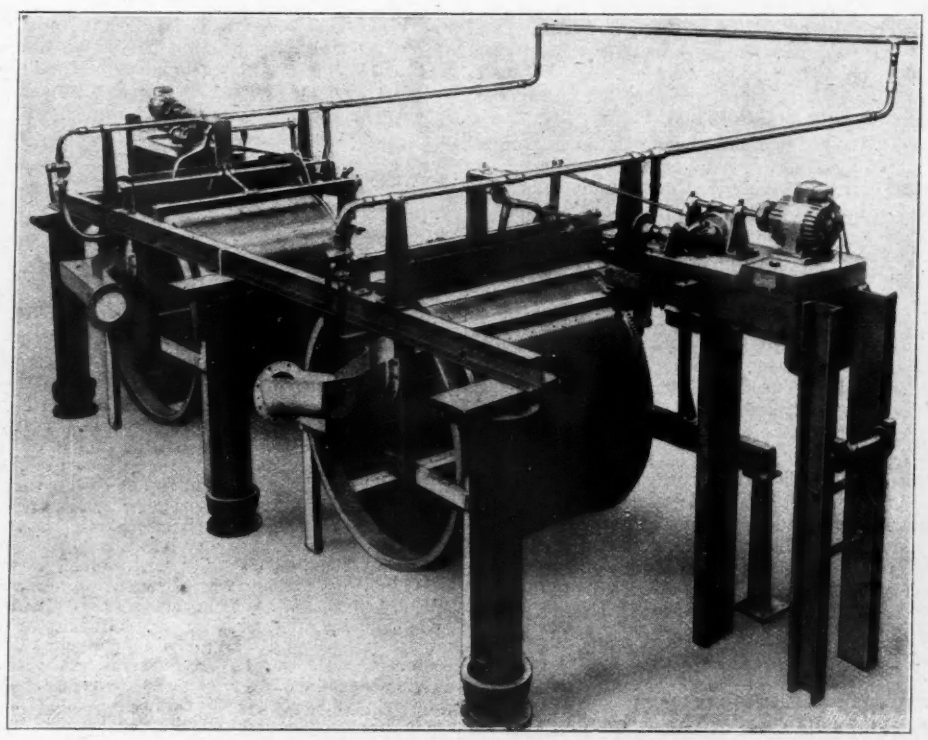

FIG. 3—PEEBLES ROTARY SEWAGE STRAINERS

woven wirecloths having apertures less than $^1/_{64}$in., corresponding to more than 40 meshes to the inch. Various degrees of fineness are available down to cloth having some 350 meshes to the inch with aperatures of the order of 40 microns (1000 microns=1 mm.).

Fine straining on a large scale is a comparatively new development in water treatment, which has hitherto been restricted by the difficulties presented by the rapid blocking of fine screens. Modern automatic self-cleaning straining plant, however, has made possible the practical utilisation of the finest weave of wirecloth, with results which approximate to the mechanical filtering action of sand beds. An example of modern automatic fine straining plant is given by Fig. 6, which shows a Peebles patent rotary self-cleaning water strainer, 5ft. diameter by 3ft. wide, fitted

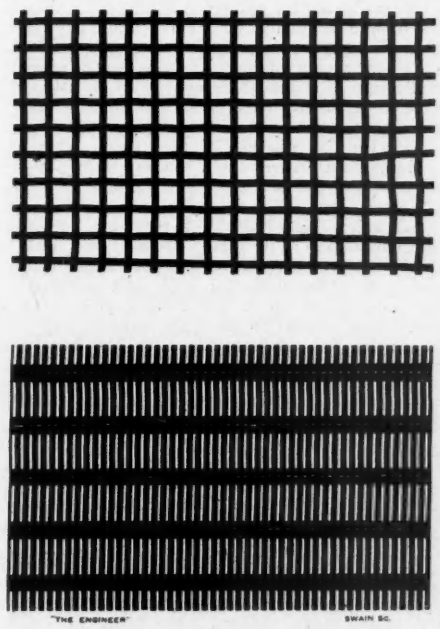


FIG. 4—SQUARE MESH AND RIBBON MESH WIRECLOTH

with 100 square mesh wirecloth and suitable for a capacity of 100,000 gallons of water per hour.

The great advantage of straining plant over filtration plant is the exceeding high capacity of strainers compared with sand filters. This is illustrated by the following table, giving filtering speeds in vertical feet per hour :—

| | |
|---|---|
| Slow sand filters ... ... ... | 0·33ft. per hour, average |
| Rapid filters ... ... ... ... | 19ft. to 38ft. per hour, usual range |
| 350-mesh wirecloth strainer | 540ft. per hour, maximum |
| " 200 " " | 640ft. " " |
| " 100 " " | 570ft. " " |
| " 40 " " | 720ft. " " |

It is not, of course, implied that strainers can be used in place of sand filters whose full function is the combined mechanical and biological purification of water, but in many cases of treatment of industrial waters, such as supplies to steel works, process water for paper mills, rubber works, woollen mills, laundries, breweries and distilleries, floating and suspended impurities are successfully eliminated by fine straining to a degree which renders further purification unnecessary. It has also been found that where straining plant is employed with the object of reducing load on sand filters, it is necessary to use the finest possible screens, as it is the finely divided impurities which quickly block the sand beds. Several important municipal water undertakings in Britain utilise automatic fine screening as the only purification process (apart from chemical sterilisation), before the impounded water is passed to service. One installation alone has a capacity of 50 million gallons per day.

### STRAINING OF COAGULATED WATER

Experimental work recently undertaken has shown that chemically coagulated water may, in certain circumstances, be successfully clarified by fine straining. The actual fineness of straining medium employed depends upon the nature and texture of the floc produced by the chemical treatment. A good example of straining plant for dealing with chemically flocculated water has been recently despatched to Burma. This plant, which is for a capacity of 1,700,000 gallons per hour, consists of four quite small automatic strainer units, fitted with 80 square mesh wirecloth having apertures of 185 microns. Working experience of this installation is not yet available.

The writer carried out some experiments with River Irvine water in Ayrshire. Samples were taken when considerable peat stain was present, together with a certain amount of suspended matter of organic and silicious origin. After treatment with lime and alumina sulphate, the colour was precipitated and a fine floc formed. Samples of the flocculated water strained through 350 square mesh wirecloth yielded a perfectly clear effluent in which visible suspended matter was absent. A photographic impression of the experiment is given by Fig. 7. It is of interest to note that the 350 square mesh wirecloth has 122,500 apertures to the square inch, each of 39 microns, and that the open area of the cloth is about 30 per cent. Very effective continuous cleaning of such fine straining cloth is necessary in working conditions, but this need present no difficulty.

### STRAINING MEDIA (WIRECLOTH)

There is little more than has been given above, to be said about bar racks and perforated plating ; but some interesting features of woven wirecloth may be described.

In general, woven wirecloth or netting may be used for most screening duties, whether coarse, medium, or fine, and the material may be selected to withstand any corrosive tendency of the water to be treated. Copper, brass, phosphor-bronze, Monel metal, and stainless steel are all metals available for wirecloth. Certain terms used in describing wirecloth are defined as follows :—

*Warp.*—Wires which run the length of the roll of cloth.

*Weft.*—Wires which run across the width of the roll.

*Mesh.*—The number of wires per inch in one direction.

*Wire Size.*—The diameter of the wires, expressed either in decimals of an inch or in millimetres. (*N.B.*—Wire gauges are best not used as these vary considerably.)

*Aperture.*—The distance between parallel wires expressed either in decimals of an inch or in microns. The aperture depends upon the mesh and the wire size and is not necessarily the same for both warp and weft.

*Weave.*—The way in which the wires are interlaced to make up the cloth.

In "plain" weave, one weft wire crosses over one warp wire and under one warp wire, whilst one warp wire crosses under one weft wire and over one weft wire, &c.

"Twilled" weave is employed when heavier wires than can be used in "plain" weave are required. Here one weft wire crosses over two warp wires and under two warp wires, whilst one warp wire passes under two weft wires and over two weft wires, &c.

Other weaves are used, such as "corduroy," "twilled corduroy," and "braided" weaves, but their use is limited to process filters, and on account of their reduced "open area" they are not generally employed for water conditioning. Various types of "ribbon" mesh wirecloth are sometimes used in water straining (see Fig. 4).

*Open Area.*—The percentage of area of cloth, when viewed in plan, which is not occupied by wire. For "plain" and "twilled" weaves the apertures are determined by the wire sizes and

FIG. 6—100,000 G.P.H. SELF-CLEANING WATER STRAINER

the mesh. They are independent of the weave if this be "plain" or "twilled," although the general shape of the aperture may be either square or rectangular with irregular outlines due to crimping of the wires. The number of apertures per square inch is the product of warp mesh and weft mesh.

The following expression for "open area" of a wirecloth applies whether warp or weft wires are the same or different in number and/or diameter :—

$$A = 100\,(1 - D_1 M_1)\,(1 - D_2 M_2).$$

Where

$A$ = open area per cent.
$D_1$ = diameter of warp wire in inches.
$D_2$ = diameter of weft wire in inches.
$M_1$ = mesh of warp wires.
$M_2$ = mesh of weft wires.

Standard square mesh wirecloth suitable for straining water and sewage is available in many different grades from the coarsest having 2in. clear apertures down to gauze with 39-micron apertures and 350 wires to the lineal inch. Some typical standard square mesh weaves are given in the following table :—

| Wires per lineal inch. | Spaces per square inch. | Aperture, microns. |
|---|---|---|
| 2 | 4 | 11,000 |
| 4 | 16 | 5,140 |
| 8 | 64 | 2,100 |
| 16 | 256 | 1,000 |
| 20 | 400 | 900 |
| 40 | 1,600 | 400 |
| 80 | 6,400 | 185 |
| 100 | 10,000 | 142 |
| 150 | 22,500 | 89 |
| 200 | 40,000 | 76 |
| 350 | 122,500 | 39 |

1000 microns=1 millimetre.

The aperture, which depends upon the wire

FIG. 5—SKELETON FRAMEWORK OF 24-INCH DIAMETER STRAINER UNIT

sizes and the mesh, falls very rapidly as the mesh is increased from 2 to 40. Thereafter from 40 to 350 the aperture diminishes much more slowly. A hyperbolic relationship exists, as can be seen from Fig. 8, which is plotted for the wire sizes of each mesh usually kept in stock by manufacturers.

River Irvine silt photographed against 350 square mesh wirecloth is shown by Fig. 9.

In choosing a wirecloth for a given screening duty, the aperture size is the determining factor. Most problems of fine screening are satisfactorily dealt with by either 40, 60, 80, or 100-mesh cloth, and on a properly designed machine any of these meshes are self-supporting in gravity flow conditions. In pressure strainers, however, coarser supporting meshes are used to reinforce the finer cloth.

Wirecloth (or gauze) having more than 100 meshes to the inch requires reinforcement even for gravity flow conditions; but there is no difficulty in arranging suitable supporting material.

### Corrosion Resistance

So far as most water supplies are concerned, no very difficult corrosion problems are encountered in relation to coarse screening plant; but precautions have to be taken for sewage installations, in which special alloys are often used for the construction of the straining medium.

When the finer meshes are in use, corrosion possibilities have to be studied if reasonable life is to be expected from the wirecloth. Taking the standard stock wirecloth in meshes from 2 to 350 per inch, it has been established that the surface area of the wires comprising the cloth

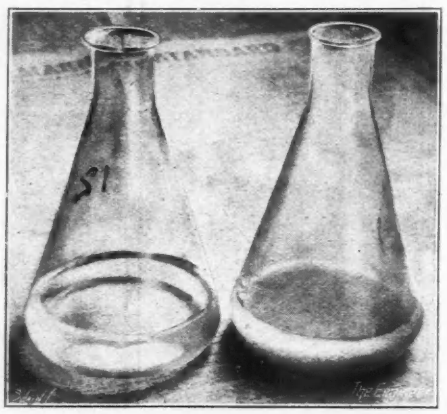

FIG. 7—COAGULATED RIVER WATER SCREENED AND UNSCREENED

(expressed, say, in square feet per pound of cloth) is almost directly proportional to the cloth mesh in wires per inch. It may therefore be said that the tendency of wirecloth to suffer from corrosion is directly proportional to its mesh in wires per inch. The ability of a wirecloth to resist a given amount of corrosion (expressed, say, in grammes per square centimetre of surface area) diminishes as the square of the wire sizes; thus the effect of corrosion becomes strongly marked in the finer meshes, and these are therefore invariably made of corrosion-resisting materials such as phosphor-bronze, Monel metal, and stainless steel. Materials available for the finest meshes are limited by their ability to be drawn down to the desired wire sizes, and this is a matter for the wire manufacturers to decide.

### Nature of Debris Removed by Straining

Natural water may contain all kinds of suspended impurities from brush, leaves, grasses, roots, pine needles, sand, and pebbles, down to fine silt and colloidal suspensions, including vegetable colour. In addition to organic and inorganic *débris* there may be present also living organisms, such as fish, insects, amœba, algæ, and bacteria. Industrial waste waters are often contaminated with various mineral dusts, such as coal and coke, animal and vegetable fibres, and gluten of different kinds. Sewage detritus may also be present in a water.

Many different treatments are used for the purification of water, their selection depending upon the impurity present and the degree of purification required, and treatment is often extended to eliminate dissolved impurities which may also be noxious. Straining, particularly fine straining, can play a very definite part in the purification of water and the subject has received considerable attention recently. Successful plant is now available for removing by continuous and automatic action the bulk of palpable suspended impurities in a water supply. Fine screening alone cannot be expected to take the place of filtration, for screening cannot eliminate bacteria, nor without chemical treatment can it remove colloidal matter. Nevertheless, for certain classes of water originally bacteriologically safe and for many industrial water supplies, fine screening is all that is required. It is often the case that screening can be economically adopted with the object of materially reducing loads on subsequent treatment plants, including sand filters.

During recent straining tests made by the writer on River Irvine water, great variations in the amount and nature of the suspended content were revealed, as would be expected, the water being

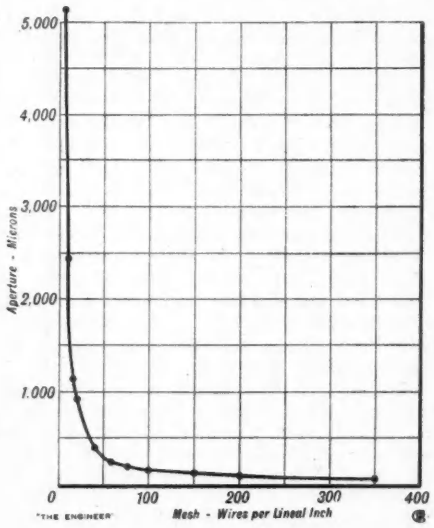


FIG. 8

practically clear and colourless in dry periods at certain seasons of the year, whilst during and immediately after rainy periods great quantities of sediment were carried, with appreciable colour. To show how screening can deal with the finest sediment in this river the micro-photograph reproduced in Fig. 9 was taken. Finely divided silt from a typical flood sample of the river water is photographed against 350 standard square mesh wirecloth. It will be seen that the particles of suspended matter are of such sizes that, although practically invisible in the original sample, they are capable of being strained out by fine-mesh cloth.

It is unfortunate at the present time that the

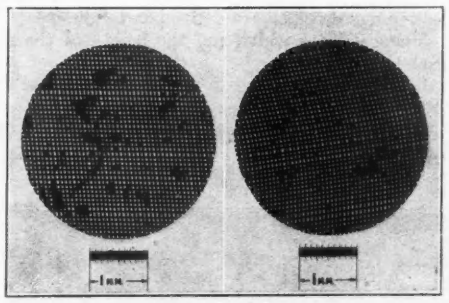


FIG. 9—RIVER IRVINE SILT AGAINST WIRECLOTH

finest meshes of woven wirecoth are unobtainable in this country. It is hoped, however, when supplies again become available that considerable development work in the finest screening processes applied to water treatment will be undertaken.

The writer wishes to acknowledge his indebtedness to Glenfield and Kennedy, Ltd., Kilmarnock, for permission to publish some of the information given above and the various illustrations.

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PITHEADS OF CONCRETE.—Mr. T. P. Stratten, in his valedictory address as President of the South African Institute of Electrical Engineers, directed attention to the fact that on the Reef crusher stations and reduction plants were almost all built in steel, whereas at present that type of construction was neither the cheapest nor in the national interest. It was incongruous, he argued, to import steel to build structures which might be built in concrete, especially when S.A. cement factories were short of orders. A S.A. contemporary has backed this up by illustrating a pithead gear constructed mainly of concrete.

## The Principles of Automatic Temperature Control*

By M. J. GARTSIDE, B.Sc. (Eng.)

THE subject of automatic temperature control is already important to those having control of certain specialised branches of engineering, *e.g.*, chemical engineering, food manufacture, bakelite manufacture and similar fields involving processes where a constant temperature is essential for the excellence of the finished product. The application of automatic temperature control is, however, much wider than to the above examples of special process work and no engineer can have failed to deplore at some time, either consciously or unconsciously, the lack of temperature control, even if it only be in relation to his own personal comfort.

In considering the subject it is important to obtain first of all a completely clear conception of the justification for automatic temperature control. Without this clear conception one may be led to the erroneous application of temperature control in an attempt to solve a problem which is in fact soluble only by correct application of basic heating principles.

Consider the heating of any body, whether it be liquid in a process tank, the mould of a bakelite press, or the air in a factory workshop. The body will receive heat from whatever source that may be chosen and will lose heat due to radiation, convection, and conduction; in many applications heat will also be removed by removal of a portion of the heated body and replacement by fresh cold material. At the commencement of the heating process all the heat input will go to raise the temperature of the body; as the temperature rises the heat losses due to the first three factors just mentioned will increase and the rate of rise in temperature will decrease until finally a point is reached where the losses balance the heat input and a steady temperature results. Theoretically, this latter position only obtains after infinite time, but for all practical purposes it can be considered to take place after a finite time which will depend upon the rate of heat input, the rate of heat loss, and the capacity for heat of the body considered.

Assuming that all the conditions remain constant, a steady temperature will be obtained; if such an assumption were correct there would be no need for temperature control. However, in practical heating applications many factors obtain which prevent the above-mentioned ideal conditions from being fulfilled, and so make necessary means of control. It is clear that increased input or decreased losses will cause an increase in temperature, and *vice versâ*, and in practice it is very seldom possible to ensure that either the heat input or losses are constant. Furthermore, in many applications heat exceeding the amount necessary to overcome the losses at the required temperature has to be provided at frequent intervals to give quick increase of temperature to the required value; it is often inconvenient to have the increasingly retarded rate of temperature rise which is the characteristic obtained when the heat input just balances the losses at the required final temperature.

*Basic Principles.*—Generally speaking, a thermostat, or temperature control device, consists essentially of an element, sensitive to temperature, which is located in the medium to be controlled. The sensitive element transforms changes in temperature into changes of mechanical dimension which, in turn, cause one of the following functions to be performed indirectly:—

(i) Reduction of heat input immediately to zero when the temperature of the sensitive element slightly exceeds the required value, and then re-establishment of heat input when the temperature falls by a slight amount. This is conveniently termed an "on-off" system of control.

(ii) Gradual decrease of heat input as long as the temperature of the sensitive element exceeds the required value by a small amount, and increase of heat input when the opposite is the case. Such a system, the increase and decrease in heat input normally being effected at a constant rate, is described as "floating" control.

(iii) Decrease of heat input with rise of temperature and *vice versâ*, the heat input being proportioned to temperature difference above and below the required temperature. This system is termed one of "modulating" or "proportioning" control.

*The Meaning of the Term "Differential."*—From a consideration of the above an important factor comes to light and that is that it is only by an actual change in temperature of the medium taking place and being transmitted to the thermostat that the latter can operate to effect the change of heat input necessary to counteract the change in temperature.

This leads to an important definition, namely, the "differential" of the temperature control system. With an "on-off" system the differential is the temperature difference between the temperature at which the sensitive element causes the heat input

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* From a Paper presented before the Manchester Association of Engineers.

to be reduced to zero with rising temperature, and that at which it causes it to be resumed with falling temperature. With a modulating system the differential is the difference between the temperature at which no heat input is given and that at which full input is given, between which temperatures heat input is varied proportionally.

It will be noted that in considering the above care has always been taken to refer to changes in the temperature of the sensitive element, and not to changes of the temperature of the medium being controlled. The differential referred to above has always been the theoretical or operating differential.

Actually, the temperature of the medium being controlled may or may not be the same as that of the sensitive element, and, what is an exceedingly important practical point, the reading of a thermometer immersed in the medium may be yet again different. Factors causing this discrepancy are :

(i) Difference in position of the sensitive element and the thermometer coupled with a temperature gradient between these two positions in the body being controlled.

(ii) If the medium being heated is air, it may be that the thermometer and sensitive element are either subject to different amounts of radiant heat or the nature of their surfaces may differ, resulting in their receiving and reflecting different amounts of heat.

(iii) When change in temperature occurs, the temperature of the sensitive element (and of the thermometer) will always change at a slightly later time than the temperature of the medium, since time is taken for heat to be transmitted from the medium to the sensitive element, and *vice versâ*.

Under what may be termed ideal conditions for temperature control, rates of change of temperature are slow, and temperature is even throughout the bulk of the medium heated. Transmission of temperature changes to the sensitive element of the thermostat is sufficiently rapid in comparison with the time required for further change of temperature to take place in the medium that the temperature of the sensitive element may be said to follow exactly the temperature of the medium controlled.

The differential measured by a thermometer in the medium will then be identical with the operating differential of the thermostat.

In practice conditions differ widely from the above and to some degree, at any rate, it is usual for the change in temperature of the thermostat to lag behind the change in temperature of the medium controlled. When this occurs it is clear that the thermostat will operate only after a change in the temperature of the medium larger than the differential of the thermostat has obtained. A similar effect may be experienced due to the heating means provided having a large heat capacity. For example, for heating an oven, heavy electric elements may be employed, which, even though switched off by a thermostat, still retain sufficient stored heat to impart a further rise in temperature to the air in the oven.

In such circumstances, which obtain to a greater or lesser degree in almost every temperature control application, it will be seen that the actual differential obtained and measured by a thermometer will always exceed the theoretical differential of the temperature control device.

*The Use of Modulating Control.*—In certain circumstances rates of temperature change may be so rapid, when full heat input is provided or heat input reduced to zero, that no practical temperature control could follow the change.

A case in point is air-conditioning work in which a continual stream of air passes through a heating battery of low heat capacity. Shutting off the heat supply completely will cause an immediate rapid fall in the temperature of the issuing air.

In such a case " on-off " control of the heat input is unsatisfactory ; full heat input must be provided only when the temperature of the medium is well below the required temperature ; heat input must be gradually reduced with increase of temperature near the control point, and the heat input must be reduced to zero only when the temperature is well in excess of the required temperature. This requires the use of a modulating system of control.

*Heat Acceleration.*—Consideration of " on-off " control, and the difference between the theoretical differential of a thermostat and the actual differential obtained in practice, suggests that if by any means the sensitive element of the thermostat could be made to receive heat from the source more directly than by conduction from the medium being controlled, then the increase in differential due to the inherent lag of the sensitive element could be avoided. This is often arranged in practice either by placing the thermostat relatively close to the heat source, so that it receives heat directly, or, as is done with electrical thermostats, particularly for the control of air temperature, by providing a separate electric heater in the thermostat, the heater being energised when the thermostat is calling for heat.

Such special arrangements have to be made with great care, as unless the additional heating effect given to the thermostat is kept within certain close limits the effect may be to give effective control of the temperature of the heating source, and hence constant heat input, rather than control of the medium.

### Design of the Thermally Sensitive Member

The sensitive element of any temperature control is invariably a matter for exceedingly careful consideration by the manufacturer, and the attributes which are important are, first, that its physical properties are such that when located in intimate contact with the medium to be controlled it shall respond as quickly as possible to changes of temperature in that medium ; and secondly, that such changes of temperature shall provide mechanical movement and force to give the maximum possible amount of work for indirectly performing one of the functions mentioned earlier.

In ordinary commercial temperature control work, the thermally sensitive element of temperature controls can be divided into the following two classes :—

*Bi-metallic Systems.*—Bi-metallic systems are those in which force and movement are obtained by virtue of the difference in expansion of two dissimilar metals. Usually, the arrangement consists of a tube of brass or other metal having large expansion coefficient in respect of temperature and a rod of a nickel-iron alloy having an exceedingly small expansion coefficient ; alternatively, the same two metals may be used rolled together in the form of a strip, the expansion of one side of the strip with increasing temperature causing the strip to bend and enabling work to be performed.

In a bi-metallic system of the rod and tube type, the movement obtained with change of temperature is small—a brass tube 12in. long expands only 0·001in. for a change in temperature of 10 deg. Fah. To offset this the force available is exceedingly large.

*Filled Systems.*—A filled system consists of a sealed bulb, which forms the sensitive element proper, and which contains a liquid having either large volumetric expansion or large change of vapour pressure with change of temperature. The sealed bulb is usually connected by capillary tubing to a sealed metallic bellows and changes in temperature at the bulb result in a corresponding change in pressure and volume of the charged system, so making the bellows expand or contract. Movement of the bellows against a spring causes operation, according to temperature, either of an electric switch or of a valve directly.

In some types of instrument, *e.g.*, for room temperature control, the sealed bellows expansion chamber is actually the sensitive bulb itself, no capillary tube being involved.

### Function of the Thermally Sensitive Member

In the above consideration of the design of the thermally sensitive member, it will have been noted that variation of temperature produces force and movement, *i.e.*, an amount of work which can be used to control the heating means in a number of ways, chief of which are the following :—

(1) One of the most common ways is the operation of an electric switch. The electric switch may control electric heating loads directly or through the medium of a relay ; it may switch the electric current to a magnetic or motor-operated hot water or steam valve, so providing " on-off " control to whatever means of heat input is employed ; or it may similarly control a motor operating to open or close dampers on a boiler, for example.

The design of the electric switch is exceedingly important, since if control of temperature within close limits is required, the mechanical work available to operate the switch is limited to a small value. The operating movement normally provided in hand or relay-operated electric switches for breaking heating load of, say, 2 to 3 kW, can be obtained only at the expense of a reduction in operating force.

The development of the " Satchwell " or micro-gap switch just over ten years ago brought to the temperature-control field a method of switching which is ideal for thermostatic work, and in the temperature-control field is the most widely employed means of switching A.C. heating loads up to 3 kW. The micro-gap switch depends for its operation upon the use of heavy contacts of high electrical and heat conductivity which are separated to a small distance only (of the order of 0·005in.). The small amount of heat generated by the short arc formed when the contacts separate is conducted away so quickly from the point of striking of the arc that with A.C. the contacts are sufficiently cool at the instant the current reaches zero in the A.C. wave, that the current does not persist after this point.

Only small amplification of the movement available from the direct expansion of a brass tube is required to provide the necessary movement of the contacts. This amplification can be obtained by the flexing of a spring lever without resource to pivots. Pivots are undesirable in thermostat design because they introduce points of wear, and the movement available for a given change of temperature is usually so small that wear is fatal to the continued accuracy of calibration of the instrument.

When the sensitive element comprises a piece of bi-metallic strip, one of the contacts may usually be mounted direct on to the flexible strip, so providing an exceedingly simple and robust arrangement, particularly suitable for room temperature control.

Another form of switch, employed to a lesser extent, is the mercury tube type, which has certain advantages when handling electric heating loads on D.C. supply. Amplification of the movement obtained from a bi-metallic system is usually necessary, and involves the disadvantage of lever and pivot arrangements mentioned earlier.

(2) The mechanical work obtained from the sensitive element may be employed to operate a valve on a gas, hot water, or steam supply line directly. In the construction of such a thermostatic valve, the vapour pressure or liquid expansion form of sensitive element is used in practically all except the smallest form of gas controls. The trapped vapour resulting from the heating of the volatile liquid in the bulb exerts pressure in the bulb, this pressure corresponding exactly to the temperature. A capillary tube transmits the pressure to the bellows which is connected directly to the valve, movement of which is opposed by a spring. Alteration of spring tension alters the temperature at which the vapour pressure overcomes the spring reaction and closes the valve. Such a device provides modulating control, since the valve takes up a throttling position dependent on temperature.

(3) For the purpose of providing modulating control by electrical means, the sensitive element may be used to move a contact over a slide wire resistance or potentiometer ; here the sensitive element chosen is usually a filled system because of the large movement required by the slider. The slider resistance so operated is incorporated in an electric circuit of the Wheatstone bridge type, in such a way that a motorised valve is caused to take up a position corresponding with that of the slider on the resistance, *i.e.*, dependent upon temperature ; alternatively, a set of motor-operated contacts may be operated in sequence to switch on more or less sections of an electric heating load according to temperature.

(4) Direct-acting thermostatic valves, similar in principle to those described earlier, may be used, not to control steam, gas, or hot water supplies directly, but as pilot valves providing increase or decrease of air or water pressure to a diaphragm, *i.e.*, pressure-operated valve of much larger size. The air or water pressure is piped to the diaphragm valve through a small orifice, and *viâ* the controlling instrument. At low temperature the thermostatically operated pilot valve allows full pressure to be applied to the diaphragm-operated valve, so opening it, while, as the temperature increases, the pilot valve directs more and more of the operating medium to a leak pipe or drain, so reducing the pressure on the diaphragm and allowing the valve to close.

(5) In a further development of the above system, the temperature sensitive element, a motor for providing oil pressure for valve operation, and the valve itself, are all built into one self-contained unit. The motor drives an oil pump which, when the thermostatic element demands heat, provides pressure on the large bellows which holds the main valve open. Increase in the temperature of the sensitive element causes this to open a small relief or pilot valve permitting release of oil from the large bellows chamber, and allowing the main valve to close. The position taken up by the valve varies exactly in accordance with the temperature.

### Choice of Type of Instrument

In considering what appears to be a large number of types of controls fulfilling similar purposes, it may be difficult to decide upon the merit or otherwise of a particular system, especially where the application is such that a number of different types will all fulfil the functions required. While it is not the purpose of this paper to make comparisons of the merit of different types as such, their broad characteristics render certain arrangements more suitable for some applications and so define the type of instrument to be used on any specific job.

Dealing with the various types in order :

(1) Bi-metallic-operated controls with short break switches are the direct means of controlling electric heating, particularly on A.C. circuits, and they are therefore almost universally applied for the control of domestic electric water heaters and for the control of electric space heating. Owing to their inherent simplicity and robustness thermostats of similar type are widely used for all general purposes, *e.g.*, boiler and calorifier control, operation of motorised valves, &c.

(2) Bi-metallic instruments incorporating mercury tubes are advantageous where a low priced control is required for D.C. use, *e.g.*, for the control of D.C. electric water heaters. The reliability is not so great as that obtained with a bi-metallic thermostat of the micro-gap switch type used with a relay.

(3) Liquid expansion or vapour pressure instruments incorporating various forms of electric switch are useful where the space available for the sensitive element is small, or where it is impossible to accommodate the switch portion near the sensitive element. Typical examples are the control of small bakelite press platens, certain types of ovens, refrigerators, &c.

(4) Thermostatic valves of the direct-operation type are generally employed for small sizes of steam-heated tank and calorifiers ; smaller types of directly

operated valves, in which the expansion of a bi-metallic tube operates a valve directly, are used in domestic gas appliances such as cookers and water heaters.

(5) Electrical thermostats operating motorised valves are applied where the valve size or the pressure of the heating medium—steam, hot water, oil, or gas, as the case may be—demand the application of more power than is available from direct operation. When employed in this way a sensitive thermostat can command an electric motor capable of developing a high torque and operating valves or dampers of large sizes. Such a system is also invaluable when the sensitive element is located at a considerable distance from the valve to be controlled. Motorised valve operation, which can be either of the on-off, floating, or modulating type, can be considered the general purpose method of providing temperature control of steam or hot water heating systems.

(6) Air or water pressure-operated valves have the same field of application as modulating electric controls, and are advantageous where it is necessary to be independent of electric supply, and where air or water pressure is available. Such systems are often employed for the control of gas-heated boilers or ovens.

## Oil-Electric Shunting Engines on the L.M.S.*

To end this paper it is proposed to sum up the main conclusions reached regarding the application of diesel traction to shunting on the L.M.S. Railway, and to consider briefly possible future developments.

A locomotive weighing about 50 tons and having an engine of certainly not less than 350 H.P. with electric transmission and capable of a maximum speed of about 20 m.p.h. appears to meet all requirements. Such a locomotive is able to show economies when compared with steam when it can be worked a sufficient number of hours per year.

This economy arises mainly from reduced fuel costs, due largely to the reduction of standby losses, the quicker handling of traffic and reduced labour costs, as there is no fireman.

It had been decided to build a further twenty locomotives similar to those designed in 1937, but this programme has been hindered by the war. The only alterations decided upon were in matters of detail.

The use of several small high-speed engines of a standard design instead of a single engine has been considered. Designs, using three or four engines, were worked out and there would be no difficulty of accommodation. The first cost would not be substantially different and the main advantage claimed would be increased availability, due partly to the ability of the locomotive to continue in service with one engine out of commission, and partly to the facility with which a defective engine generator unit could be replaced by a standby set. Fuel costs would probably be about the same, and by using standard engine generator sets maintenance costs might be no greater. Weighing all the circumstances, however, there was no gain in changing, and at this juncture a standard engine is an asset from the maintenance aspect.

Having decided on a single engine, the lay-out of the locomotive is settled to a large extent. For example, the driver's cab is most conveniently situated at one end of the frame, and this appears to be the best position from the operating point of view.

It has already been explained that the traction motor or motors should be force ventilated and should drive through double reduction gears. With a single motor mounted on the frame the most convenient drive is by means of a jack shaft and coupling-rods. This entails some heavy and expensive mechanical construction and also necessitates the use of side rods, which require accurate maintenance to ensure satisfactory working. The difficulty, however, is not so serious in low-speed shunting units as it is in high-speed locomotives, and in actual fact the maintenance of this form of drive has not given rise to any trouble.

However, a design of locomotive with nose suspended motors and double reduction gears has certain advantages.

If the design of the jack shaft locomotive is analysed it will be seen that there is little latitude in the position of the motor in relation to the wheel base. The position of the driver's cab being fixed, the position of the diesel engine and generator must follow, with the result that the balance of the locomotive is bad, and unless the body is long as compared with the nose-suspended motor type, the machines in the body are cramped. Further, the frame of the locomotive has to take the reaction of the drive and has consequently to be stiffened ; the wheel base, too, must be long enough to permit the accommodation of the jack shaft and the springing arrangements are not too good. The gear case for the second gears is a difficult and expensive piece of work and the load on the final gears is high. The jack shaft locomotive at the time it was introduced had certain merits, however. A forced ventilated motor with double reduction drive must be used, this limits the maximum speed at which the locomotive can be moved, and when a jack shaft locomotive has to be hauled dead the connecting-rods can be removed and the locomotive attached to an ordinary freight train.

The development of similar facilities with double reduction nose-suspended motors has now been achieved ; the motor is force-ventilated and the intermediate shaft carrying the first gear wheel and the second pinion can be drawn out of mesh, incidentally, in much shorter time than is required for dismantling the connecting-rods of the jack shaft type.

With the nose-suspended motor the position of the engine generator unit is not limited and it can be placed to give good balance and accessibility. The body can be shorter, the wheel base is shorter, and the springing arrangement is simple. The large gear and gear case of the jack shaft type is avoided, and as two motors are used the loading on the gears is lower.

A locomotive has been fitted up for trial to try out the arrangement fully. The locomotive chosen is one of the type listed under 12 in the Appendix,* the only change being the substitution of force-ventilated double reduction motors for those existing. Trials have shown that the limitations of this type in comparison with the jack shaft locomotive have been overcome. The first cost of a new locomotive would not be greatly altered by the change in design, and the total weight would be somewhat less, which would be an advantage.

Having settled the main features of a design it is necessary to concentrate on the details in order to secure simplicity and reliability so that capital and maintenance costs can be reduced and the availability increased. It is on this that the extent of future development mainly depends.

One point to which considerable thought has been given is the method of starting the engine. The method adopted on all the units with electric transmission of motoring the generator from the battery is technically satisfactory, provided the battery is maintained in good condition and is kept sufficiently charged. A few cases have arisen where, due to a faulty or incompletely charged battery, coupled possibly with some mistake on the part of a driver, an engine has failed to start. But the good results from battery starting have been obtained only by making the rather severe stipulation regarding starting, mentioned earlier in the paper ; this necessitates a heavy battery which has often to deal with only one heavy call per week, *i.e.*, when starting after standing over the week-end. Starts during the week are not only small in number, but also require only a short discharge. To meet this duty a lead battery costing about £200 or an alkaline battery costing about £300 is needed. The former has a life of, say, four years and the latter should last appreciably longer, but in either case an annual cost of about £50 per locomotive is incurred, which makes the battery the most expensive single item on the locomotive.

Various alternatives have been considered. A separate starting motor or motors, driving through Bendix or other high-ratio gear systems, would reduce the size of battery needed owing to the higher electrical efficiency so obtainable, or the battery might be still further reduced by using it to start an auxiliary diesel engine which would in turn start the main engine. A petrol engine would be cheaper for such a purpose, but it is not desirable to carry petrol on the locomotives, quite apart from the added complication of having separate tanks to keep filled. An air motor might be used, but even with a large reservoir a separate engine-driven compressor would be desirable. Direct air starting is not favoured.

Experiments are being made with different materials for cylinder liners, valves, bearings, &c., but it has not yet been found possible to come to definite conclusions. The problem of wear is also being tackled by improving the cleanliness of the lubricating oil and of the engine generally. By-pass filtration circuits have been added to the lubrication system of some engines, and various proprietary filters, including magnetic filters, are being tried. Again, it is difficult to come to any quantitative conclusions, although it can be said that filtration is very desirable.

For new locomotives it is intended to adopt a modified ventilating system in which the air passing through the engine radiator is isolated from the engine compartment. This compartment will then have a common ventilating system with the electrical equipment, taking in air through a filter.

Filters on the engine inlets will, of course, be retained.

Certain points of engine design are still under consideration. One of these is the use of valve seats, integral with the cylinder head, instead of the caged valves, *i.e.*, valve and seating withdrawable from the cylinder head as a unit, used on the majority of the engines now in service. The integral seat obviously lends itself to better port design and is cheaper in first cost, but unless the valves can be left without attention between major overhauls, the caged valve must be employed owing to the delay and cost of removing the cylinder heads to attend to non-caged valves.

As the periods between overhaul are lengthened the caged valve becomes more advantageous and the solution will probably be to use the caged type with the stellite or chromium treated valves which are being tried at present.

Another matter to which thought is being given is the use of over-size pistons. Although at first sight it would seem an obvious economy to bore out worn liners and to have a system of purchasing over-size pistons which would be turned down through a series of standard sizes as they became worn, in the author's opinion the complication of maintenance procedure and storekeeping and the change in engine conditions makes them undesirable, especially with the rate of liner wear it seems will be obtained.

It will be seen from this brief *résumé* that the diesel electric locomotive for shunting duty has come to stay, but there are still many points where improvements can be made to cheapen maintenance costs and to lessen capital charges, and wider experience will give the data to deal with these adequately. The L.M.S. Railway expect to get this experience rapidly as the number of locomotives in service is to be substantially increased.

* Being the conclusion of a paper entitled "Diesel Shunting Locomotives" presented by Mr. C. E. Fairburn to the Institution of Locomotive Engineers on April 30th, 1941.

* The engines are 0–6–0s built by the English Electric and Hawthorn-Leslie in 1936. They weigh 51 tons and the standard rating of the oil engine is 300 B.H.P. at 600 r.p.m. There are two self-ventilated 4-pole motors for a continuous rating of 140 H.P. each. The gear is single-reduction 4·38 : 1.

## American Industrial Research

INDUSTRIAL research—that is, research carried on by scientific methods, but with the definite purpose of achieving some result of practical benefit or value in industrial or commercial lines—is conducted in many public and private institutions in the United States, and is exemplified in a report of the Armour Research Foundation, of Chicago. This report reviews progress in the numerous and varied activities of the institution. Many of the subjects are suggested and sponsored by manufacturers or other interested parties, who defray a share of the expenses involved, while other subjects are initiated by the technical staff. As examples, a fundamental study of combustion in oil engines is sponsored by the Caterpillar Tractor Company ; the application of catalitic methods to oil processing (hydrogenation, dehydrogenation, isomerisation, cyclisation, and polymerisation) is being studied for the Universal Oil Company, and the standardisation of golf balls is being studied on behalf of the United States Golf Association. Some typical subjects of research as conducted by the Foundation are noted in the following matter.

Coal as fuel is being investigated in different ways. Methods of drying wet washed coal involve laboratory and field work, with various types of commercial driers, together with drainage, storage, and car loading. Another line of investigation covers materials and methods for dustproofing coal, and has developed new and cheaper methods for such treatment. Attention has been given to materials which can be applied easily under adverse conditions, such as very cold weather. Tests have been made under full-scale industrial working conditions in mines, retail coal yards, and railway and steamer shipments. A special aspect is the development of materials to be used at working faces in mines to reduce the amount of dust held in suspension, thus reducing the explosion and health hazards.

In pulverising coal by swing-hammer machines there is a severe problem, but study of design and of metallurgical details has resulted in greatly increased life of the hammers. Stoker research, undertaken for a manufacturer, includes materials for construction, details of design, corrosion, and the relation to friability of coal and the effects of coal treatment. For profitable utilisation of the enormous accumulations of coal dust, a study of colloidal fuel has resulted in the production of a liquid fuel containing 50 per cent. coal and suitable for use in locomotives, steamships, and power stations. It has been fired in furnaces with ordinary oil-burning equipment. Relation of motor fuels to such matters as wear of piston rings and power development in automobiles is being studied in the laboratory, and also in a series of automobiles, using approved dynamometric methods.

Studies for the improvement of travelling cranes have developed a new type of precision lowering system which makes possible the elimination of mechanical brakes. Another improvement is a two-motor drive for the travel of crane bridges of long span, eliminating mechanical power transmission. Improvements in A.C. solenoid brakes for cranes eliminate the usual shock and hammering. An oil-immersed solenoid was developed which operates with unusual quietness and smoothness. Tests are in progress for an investigation to determine the resistance to abrasion of special grades of steel for use in the manufacture of gears.

An important scheme is the improvement and development, on a commercial basis, of the Wetherill process of counter-gravity pressure die casting of grey iron and other metals having high melting points. The process includes the use of an enclosed pressure-tight crucible withstanding considerable internal pressure. The die is placed above the crucible and the metal is forced from the bottom of the crucible, against gravity, into the die, the internal shrinkage being fed as the casting "freezes" progressively from top to bottom. This study is being conducted in a new foundry building which has a cupola handling 3000 lb. per hour.

With the use of new devices for the measurement of vibrations, an extensive survey has been made in and around a large drop forge plant in order to determine the magnitude of the vibrations resulting from the operations of the forge hammers. Another line of study is the reduction of noise in the operation of calculating machines, and the measurement of noise level on various kinds of machinery, as well as on office and theatrical equipment. Research in the processing of hemp has resulted in the production of hemp fibre that is comparable in many respects with the best grades of cotton, and work is now centred on making the process commercially economical and practicable.

Of a different kind is a study promoted by an association of manufacturers of clay pipe for sewers, for the production of an improved jointing material for bell and spigot pipes. Joints in such sewers must remain permanently water-tight to prevent leakage and to exclude tree roots in search of the slightest trace of moisture. The material must also be unaffected by the acids and alkalis of sewage, industrial wastes, and the chemical compositions used for cleaning household drains. It must not shrink, harden, or become brittle under the influence of time, air, and water, and it should adhere permanently to pipe that is wet, dry, muddy, or greasy. While a perfect composition has not been reached, a composition has been developed that meets a number of the requirements, and is adherent to both glazed and unglazed pipe. The material is melted in an open kettle and is poured into the joint at about 250 deg. to 450 deg. Fah., using the ordinary form of runner. This material has been used particularly in the joints connecting house soil pipes to the street sewers, which is the place where tree roots usually cause the most trouble. But it is applicable also for the main sewers. Accelerated tests are being made in California, where fast-growing trees are available, whose roots will be attracted by the slightest leakage. Continuous year-round tests are being made also at greenhouses in Chicago.

Improved dolomite refractories have resulted from research undertaken for the Marblehead Lime Company, and the first phase of the study—on clinkered dolomite refractories—has been concluded. This study is said to have developed the mineral character and uniformity of the product and the effect of variations in flux and raw material constituents upon the manufacture and properties of dolomite clinkers. It resulted in improvement of quality and uniformity and a decrease in cost of manufacture. The possibilities of dolomite brick as an alternative to the more expensive magnesite brick has long interested producers of refractories, partly on account of its characteristics as a refractory, but mainly on account of its greater availability close to the centres of industry. One of the problems is to stabilise the lime from the lolomite so that it will not slake and cause disintegration. Porosity and cross-breaking strength are being studied, as well as grain size and the use of binders.

As a factor in the widespread problem of housing, active study has been made in the development of light-weight concrete for low-cost housing construction, with a necessary combination of low-heat conductivity and ample bearing strength. It appears that a building wall constructed with blocks of such light-weight concrete, with plaster applied directly on the interior surface, will be comparable with dwelling-house walls of ordinary construction. In research on the compressibility of liquids, attaining hydrostatic pressures up to 1,500,000 lb. per square inch, it has been found that the compressibility is much greater than has been generally understood.

Golf and fountain pens are two rather unusual subjects of scientific research. In the former, at the instance of the United States Golf Association, a machine has been devised and calibrated for driving golf balls and measuring the velocity of flight, the machine being adjusted to strike a ball with the force comparable to that delivered by the average player. It is expected that this machine will enable manufacturers of golf balls to standardise their methods and materials to such an extent as to produce balls approaching much closer to standard performance than is now the case. As to fountain pens, the study initiated by a manufacturer is said to be an excellent illustration of the application of scientific measurements to an industry guided largely by "rule of thumb." There was first an experimental physics study of the operation of fountain pens, including a quantitative study of the interdependence of the various parts. This led to the design of a pen in which every part could operate in its optimum relation to all other parts. The pen so designed was found, upon careful test, to be superior to other pens similarly tested.

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CONTROL OF BALL AND ROLLER BEARINGS.—The Control of Ball and Roller Bearings (No. 1 Order), which came into force on April 30th, prohibits the purchase or acquisition of any ball or roller bearing, except from the bearing manufacturers or for use by the purchaser in production or maintenance of some other article, or under a licence issued by the Minister of Supply. All inquiries should be addressed to the Bearing Panel, Ministry of Supply, Great Westminster House, Horseferry Road, S.W.1.

# Markets, Notes and News

**The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer**

### Conditions in the United States

With the resumption of coal mining the blast-furnaces immediately restarted, although it may be the end of this month before coke deliveries at Pittsburg and the chief producing districts are sufficient to maintain full operations. During April twenty-five blast-furnaces were either idle or only partly operative. Prices are unchanged with No. 2 foundry at 25 dollars, Bessemer at 26 dollars, and basic at 24·50 dollars, f.o.b. furnaces, Eastern Pennsylvania. Orders are invoiced at the price ruling on the date of shipment, and producers are asking for an increase in prices to cover the advance in costs as a result of the higher mining wages. In the New England market the price of foundry coke at the local by-product coke ovens has been advanced by 75c. per ton. The output of pig iron in 1940, according to the American Iron and Steel Institute, totalled 47,398,529 tons, including 1,326,863 tons of ferro-alloys. In the scrap market there is a scarcity of heavy melting grades, which developed during the coal mining stoppage, when larger tonnages were used to augment supplies of pig iron. The British inquiry for 75,000 tons of scrap is not yet placed. Prices are officially controlled and for railway heavy melting scrap are 21 dollars, Pittsburg, and Youngstown delivery, and 19·75 dollars delivered Chicago and Eastern Pennsylvania. No. 1 heavy melting steel scrap is quoted at 20 dollars and 18·75 dollars for the respective delivery points. The output of steel is expected to show a prompt rise with the resumption of coal mining from the present rate of 94 per cent. capacity at Pittsburg, 96·5 per cent. at Chicago, and 90 per cent. at Birmingham. The sheet mills are working at a good rate and bookings are now being taken for first quarter delivery, 1942. Buying by the railways has been active and orders for freight cars recently placed aggregate more than 4000. The pipe and tube mills are actively employed on oilfield and building requirements and are working at near to capacity. In the tin-plate department the mills are operating at about 85 per cent. The total output of steel ingots and castings in 1940 is given as 66,982,686 tons, as against 52,798,714 tons in 1939.

### The Pig Iron Market

One of the most interesting developments affecting this market since the collapse of Belgium and France, from the point of view of the British blast-furnaces, has been the expansion in our home output of iron ore. There has been a considerable increase, and this constitutes a valuable saving in shipping space—a vital contribution to the war effort at the present time. Of course, as the domestic iron ore is of lower-grade than the best foreign varieties, the output of pig iron per ton of ore is naturally lower, which means a higher production cost, but in war-time cost factors play a minor part. The intensification of "black-out" measures in the iron and steel producing districts is involving the managements in large expenditure, but the problems involved seem to have been largely overcome, though possibly the question of ventilation will have to receive further consideration. Should the Battle of the Atlantic, in some of its phases, throw Britain back more fully on her own resources, the recent stimulation of the iron ore industry here will be acknowledged as having been a sound move. There is no shortage of pig iron in this country; in fact, the makers of foundry iron could probably deal with a larger demand, since the slump in private building has resulted in a prolonged absence of buying of light castings. Some of the heavy founders are, on the other hand, well employed, since big castings are in demand from the engineering trades which are fully engaged on war work. Steel-making irons, such as hematite and basic, are, of course, under continued heavy pressure. Some consumers' demands are being met by alternative materials, whilst imported descriptions are also available. Close supervision is generally exercised over the distribution of all pig iron supplies by the Control, and there is little reason to expect that this supervision will be relaxed as the year wears on, since the possibility that imports may be interrupted from time to time by enemy action in the Atlantic must not be lost sight of. For the time being, however, there is no particular difficulty in obtaining consumers' licences for reasonable requirements. High-phosphorus forge pig iron is in comparatively plentiful supply.

### The North-East Coast and Yorkshire

Priority consumers of steel are now obtaining deliveries with greater dispatch than some little time ago, the chief explanation being not that the demand has fallen, off, but that supplies to non-essential users have been very drastically cut down. The position, of course, is helped by the steady importation of large tonnages of steel of all kinds from overseas, particularly from the United States. One or two factors may possibly reduce these arrivals temporarily; for instance, the recent coal strike and the accompanying reduction of output at the blast-furnaces and steel works, and the holding up of British contracts for carbon steel. This phase, however, is not likely to be of long duration, and when the new methods of American naval assistance come into full application the stream of imports may become a torrent. A considerable amount of scrap, pig iron and steel is reported to be awaiting shipment at the United States ports. Meanwhile our own iron and steel industry is doing everything possible to increase the home production, and the supply position here at the moment is entirely satisfactory. The mills rolling heavy structural steel could, indeed, probably handle more business than they are getting, but the demand seems to be broadening out again. There is intense pressure on the producers of light structural steel. As a consequence of the shipbuilding drive plates are in heavy request, and the demand in this direction is still on the up-grade. In the Yorkshire area the steel industry is operating at full blast. Special steels are a speciality of this district and these are in intense demand for war purposes. No shortage of semi-finished materials is reported.

### Scotland and the North

There is every reason to believe that consumers in Scotland, as well as in other parts of the country, have been obtaining their essential supplies more freely than hitherto. This can be ascribed mainly to the fact that the curtailment of steel allocations for non-priority work is releasing considerable tonnages for more important branches of industry. The situation here has been further assisted by the good imports of pig iron, semis, and finished steel from overseas, especially from the United States. Supplies of most kinds of iron and steel in Great Britain are on a satisfactory scale, and the Control will doubtless do all in its power to ensure that our war factories can operate with a safety margin as far as stocks are concerned. Heavy structural steel remains a comparatively dull spot, partly owing to the fact that much of the programme of factory, aerodrome, and similar construction must have by now been completed. Nevertheless, there is a tendency towards improvement in this section of the market. Light structural steel, on the other hand, is in intense request. The shipbuilding boom is calling for a huge demand for plates and other shipbuilding steel, and this state of affairs is likely to continue indefinitely, in view of the big programme of shipping construction now in hand, particularly in Scotland, where special measures have been taken to broaden the movement. Many steel masters, however, are complaining of a shortage of scrap iron and steel. Engineering and constructional works of all kinds are busy on Clydeside, and this results in a big call for tank and boiler plates, iron and steel bars, sections, castings, and other materials. Tubes are in active demand, and there is a steady call for bolt and nut iron. The re-rolling mills producing small steel bars and light sections are well employed, and appear to be obtaining enough semis to keep them going on a full scale. Although they report a slight falling-off in demand, the mills, nevertheless, possess good order books. The sheet mills, including the galvanising works, are experiencing boom conditions. In Lancashire there has been some slowing down in the demand for one or two products, including bar iron and foundry pig iron, but in view of the heavy pressure on the industry generally, this has been welcomed rather than deplored by producers.

### Copper and Tin

With the intensified German attack on our shipping it is obvious that the greatest care will have to be maintained in the allocation of strategic raw materials, such as copper. It is almost certain that only the more important Government requirements will continue to get full supplies, and some further restrictions on the use of copper and brass for non-essential purposes have already recently been enforced. Manufacturing activity here is maintained on a large scale, and it is anticipated that national requirements will continue to keep the sheet, wire and tube mills busily employed, whilst brassmakers will also be active in all departments. In the United States the demand for copper continues unabated. Consumers there have applied for something like 100,000 short tons of Government imported metal for May delivery, but allocations reached only 39,000 tons. It may be possible to get a clearer view of the actual American supply position after the end of this month, when new purchases of copper will only be permitted after the Government has had an opportunity of examining the stock position of the works. . . . American tin consumers continue to display nervousness over the maintenance of supplies of that metal from the Eastern producing centres, and have been buying substantial quantities at well over the Metals Reserve Company's fixed buying price. This applies also to the United States Navy Department, which last week bought 250 tons at around 51·60c. per pound. In Great Britain the demand keeps fairly steady, but dealings on the open market have been rather quiet on the whole. The Government is offering metal here almost daily, but on occasion its selling price has been a little above the market level. Nevertheless, it is pretty certain that the existence of these Government offers is helping to hold the market here in check, particularly as regards spot tin, and without this restraining factor the backwardation might have widened still further.

### Lead and Spelter

The Government requirements of lead in connection with the war effort, notably in the form of cables and batteries, remains large, but there is an adequate supply to meet all essential needs. There is still a certain amount of this metal being allocated for other than war purposes; but the amount available in this connection is likely to be somewhat reduced, partly owing to the concentration of industry and partly owing to the need for economising in the use of shipping. Firm conditions continue to prevail in the American lead market, where the domestic demand is greater than the supply; but the balance is being met by imports of foreign lead, mainly Mexican, supplies of which for the time being are proving ample. The spelter situation remains strong on both sides of the Atlantic, the demand being maintained at a high level. In Britain, not only are the brassmakers working at top speed, but the die casters also are using substantial quantities of zinc alloys, and the galvanisers have big Government orders on hand calling for considerable quantities of g.o.b. metal. In the United States, thanks to the virtual elimination of reserve stocks in producers' or Government hands, deliveries have been brought down to the current rate of production, which in April was about 63,000 short tons. Undoubtedly, consumers there would buy substantially larger quantities if they could get them, but there is little expansion to be seen in the domestic production, although an upward tendency should soon become apparent. Whilst official priorities have not been imposed on zinc in America, there is perhaps closer control over the allocation of this metal than over most others.

# Notes and Memoranda

## Rail and Road

INGOT BOGIE.—Referring to a paragraph in this column describing a monster American truck, Head, Wrightson and Co., Ltd., remind us that they have recently completed a similar "bogie" designed to carry ingot moulds of 300 tons. It is carried on four three-axle trucks, and in order to keep the tare weight down it is of all-welded construction. The tare is only 69 tons, as compared with the 140 tons of the American bogies for a substantially smaller load.

SWEDISH PRODUCER GAS VEHICLES.—More than 90 per cent. of the Swedish motor traffic is now being operated on producer gas. The number of producer-gas vehicles in the country amounted to 45,000 at the end of March, of which about 60 per cent. used charcoal as fuel and 40 per cent. wood. The Swedish State Railways have at present over 100 producer gas driven rail buses in traffic, and new vehicles have been ordered. The private railways too, are operating their rail buses on producer gas.

BOSTON-WASHINGTON SUPER-HIGHWAY.—Plans for a "super-highway" from Boston to Washington have been under consideration since the Public Roads Administration made its report on "Toll Roads and Free Roads" in 1939. They have now been carried to the point of laying down a tentative route and making estimates of the cost of such a highway. The length is put at 405 miles and the cost at 253,000,000 dollars, and the estimates are based on building as many as twelve lanes in regions of dense traffic.

RAILWAYS IN SWEDEN.—Owing to the scarcity in Sweden of imported fuel, both liquid and solid, all coal-fired railway lines have recently received instruction to reduce their traffic and to use wood fuel as far as possible. It is hoped by this means to bring down the coal consumption of the railways by 50 per cent. The effects are expected to be limited, since Sweden is fortunate enough to have had all her most important lines electrified, the electricity being generated by water power. Of the 9700 kiloms. of State-owned railways, more than 3800 kiloms. were electrified at the beginning of this year, and on these electrified lines about 90 per cent. of all the goods and passenger traffic of the Swedish State Railways was carried. Sweden's private railways own nearly 7000 kiloms. of line, of which about one-tenth is electrically operated.

EXTRA HEAVY PARCELS.—Delays are being caused to passenger trains owing to the large quantities of heavy parcels which are being despatched. Valuable time is lost in handling very heavy or bulky packages which have to be loaded and unloaded and transferred from one train to another, and this is reacting on the general train workings. The railways have liberated a large number of men for H.M. Forces, and women are being employed in increasing numbers, in addition to men who have not the experience of the regular staffs. The result is that the speedy transit expected by passenger train services cannot be given, although the railways are making every effort to provide the same facilities as in peacetime, when 90,000,000 parcels a year were forwarded. Senders can assist the depleted railway staffs by packing lighter parcels, crates, boxes, trunks, &c., which must be forwarded by passenger services, and so make it easier and quicker for women porters to handle the packages. Even in the case of urgent machinery, perishable foodstuffs, &c., every effort should be made to keep the weight of each package below 112 lb.

## Air and Water

TRAWLER LOSSES.—The Board of Admiralty regrets to announce that H.M. trawlers "Rochebonne" and "Kopanes" have been sunk.

R.A.F. ELECTRICIANS.—It is announced that skilled men between the ages of eighteen and fifty in certain electrical and mechanical trades hitherto reserved may now volunteer for service in the Royal Air Force.

SHIPYARDS AND ESSENTIAL WORK ORDER.—In answering a recent House of Commons question, the Minister of Labour stated that up to May 2nd the number of undertakings scheduled under the Essential Work (Shipbuilding and Ship Repairing) Order was 284.

AMERICAN AEROPLANE OUTPUT.—It has been disclosed in Washington that American aeroplane production in April reached 1493 machines; 414 aeroplanes, valued at £6,250,000, were sent from America to Great Britain in March, compared with 258 in February.

THE "CALIFORNIA CLIPPER."—The "California Clipper" reached Singapore on Saturday, May 10th, having opened the new Pan-American Airways' San Francisco and Singapore service. For the last few miles of her journey she was escorted by five R.A.F. Brewster and Ship Repairing) Order was 284.

INSTITUTION OF NAVAL ARCHITECTS, PAPER NO. I.—With reference to the eight papers to be published with a view to discussion, and announced in our issue of April 4th, we are informed by the Institution that Paper No. I, by Mr. Wilfred Ayre, on "Features of Wartime Shipbuilding," will not, on account of business and other considerations, be presented by Mr. Ayre for the current year's "Transactions."

THE AMERICAN FORD COMPANY'S AERO-ENGINE ACTIVITIES.—The Ford factory at Dearborn is well on the way to contributing a large share in the production of aero-engines. Engines of 1250 H.P. for America's largest bombers will shortly be in production. Part of the scheme has involved the building of a very large foundry for light aero castings. The factory proper, which is in process of erection, will, when in full swing, be capable of producing between 700 and 1000 engines a month. Another project is the building by quantity production of the aircraft frames for the "Consolidated" bomber ready for assembly. The company's designers are also busily engaged on a simplified aero-engine developing 1500 H.P., suitable for production by the Ford methods.

THE MADERA CANAL.—It is reported in *Engineering News-Record* that the construction has been started at Friant dam of the first link of the 38-mile Madera Canal. The initial work involves excavation, concrete lining, and construction of operating works, including three siphons under Cottonwood Creek, and two smaller streams. The first 10 miles of work will advance the canal from Friant to a point northward near the Yosemite highway.

NORFOLK FLOOD DAM, ARKANSAS.—It is expected that work will begin shortly on the construction of the Norfolk flood control dam in Baxter, Arkansas, on the north fork of the White River. The dam is to be 220ft. high and 2624ft. long and will create a lake with a 50-mile shore line. The Arkansas Power and Light Company is now completing a 110,000-volt line through Norfolk from Batesville to make power available at the dam site for construction purposes.

## Miscellanea

AMERICAN COBALT.—A project, which has been in abeyance for some time, for the manufacture of cobalt metal and oxide in America has been revived and seems likely to mature. Among the recent certificates of plant expansion issued by the National Defence Advisory Commission at the end of February is one authorising the African Metals Corporation of New York to expend 570,000 dollars on the production of cobalt metal and oxides.

THE LATE PILOT OFFICER G. G. SHARP.—The death is announced through enemy action of Pilot Officer G. G. Sharp, R.A.F., V.R. George Guy Sharp was trained at the Metropolitan-Vickers Electrical Company's works at Trafford Park, and on the completion of his course went into the mining department. He was sent out to the company's Johannesburg offices in 1937, and returned to the mining department in 1939. He was one of the company's promising engineers, and his loss is greatly regretted by his colleagues.

LIGHT FOR CHEMICAL CONTROL.—The value of fluorescent tubular lamps in industry has been mentioned before and their use is extending. The Crompton-Parkinson interests have just adapted a battery of four 80-watt fluorescent tubular lamps to the control of a special chemical process in a Government factory. The process involves the addition of acids to a chemical solution by carefully controlled stages, as a result of which the liquid changes in colour, which changes determine the point at which the next step must be taken. The fluorescent tubular lamp provides controlled light more constant in character even than daylight.

BORNEO HAS IRON.—Preliminary investigations of iron ore deposits on the island of Poeloe Danawan, off the south coast of Borneo, are not regarded as encouraging. Although the Bureau of Mines of the Netherland Indies estimated the deposits contained about 3,500,000 metric tons of iron ore, no large deposits that could be worked at a profit were discovered. A syndicate is reported now to have under consideration the exploitation of deposits on the mainland of Borneo. The principal obstacle in the way of developing this industry appears to be the difficulty in finding an outlet for production in view of the fact that Europe, British India and Australia are self-supporting.

NICKEL IN FINLAND.—Uncertainty still surrounds the production of nickel in Finland. The Soviet Government is said to have demanded from Finland the transfer of control over Petsamo nickel from the British owners to Russia. The mines were developed by the Mond Nickel Company, the British branch of the International Nickel Company of Canada, and when war broke out in Finland last year the mines had nearly reached production stage. Information from neutral sources suggests that though the mine buildings have suffered, the damage to the mine itself was not serious. Soviet nickel requirements are some 7500 tons a year, with domestic output from the Urals only about 2800 tons a year. Finnish ore would be of little use to Russia unless the smelting works were restored and completed.

THE AMERICAN FORD COMPANY.—During the year ended November 30th, 1940, the Ford Company's employees throughout the United States averaged 113,628 hourly wage earners, not including office employees, students, or executives. They were paid 185,105,639 dollars (roughly £37,000,000). On this basis the average annual wage was 1629 dollars (roughly £320). The company has no age limit for workers. The average age of its workers is 38·7 years. The youngest worker is 18; the oldest, a railwayman, is 87. Nearly one half of the workers are 40 or over. In addition to the regular employees, the company has engaged thousands of workers who are blind, crippled, or otherwise unsuitable for normal productive work, at the same regular hourly wage. There are more than 10,000 such workers.

ROCK BURSTS.—Canadian mining engineers are considering a natural phenomenon known as rock bursting. The first recorded burst was at the Kirkland Lake Gold Mine in 1929, although miners had noticed pressure effects in other mines at an earlier date. Since then bursting has occurred in the Macassa, Teck-Hughes, Lake Shore and Wright-Hargreaves mines in the Kirkland Lake field, and at Sudbury and other mining centres. Efforts of mine operators have so far prevented anything in the nature of a catastrophic rock burst, according to Professor G. B. Langford, of Toronto University, who is studying the matter. He stated that rock bursting is probably the most complex problem that the mining industry has ever had to cope with. Until a great deal of experimentation and theoretical study have been made the theories advanced so far to account for rock bursts cannot be considered as more than ideas, and must be treated as such.

FLOUR MILL IN CORDOBA.—A story of high accomplishment has been told in a recent issue of the *British Chamber of Commerce Journal*. A new flour mill is being put up at Cordoba for Minetti and Co., of Rosario, Argentina, to succeed one which was completely destroyed by fire a year ago. The contract for replacement was given in the third week of May, 1940, to a firm of milling engineers in the North of England, the owners stipula ing that the bulk of the heavy machinery must be shipped by the end of August. Considerable overtime had to be worked to bring about what in peacetime would have been an achievement. The amount of machinery involved was 1750 shipping tons of 40 cubic feet, and the firm's head erector has now gone to Cordoba. The new mill will have an hourly capacity of fifty sacks of flour of 280 lb. each.

BATAVIA FOR BAUXITE.—The Royal Ba'avia Society of Arts and Sciences has discussed prospects for local manufacture of aluminium from bauxite obtained from the island of Bintan. Economic transportation of bauxite from the Riouw Archipelago and adjacent islands to the site of the power station now being constructed on the Asahan River in East Sumatra is a possibility. The quality of bauxite deposits on the island of Bintan, which is near Singapore, was mentioned especially, and costs of mining bauxite are no higher than elsewhere in the world. A preliminary estimate places the potential energy of the falls at about 900,000 H.P., and consumption of electrical energy for the production of aluminium alone at this site at 200,000,000 kWh per year, equal to the consumption of the State mines and nitrogen extraction plant in the Netherlands.

THE LATE MR. T. O. CALLENDER.—We regret to learn that Mr. Thomas Ormiston Callender, A.M.I.E.E., a director of Callender's Cable and Construction Company, Ltd., died on May 10th, 1941, at Bidborough, Kent, at the age of forty-five years. He was educated privately and at Cambridge and during the Great War served as a lieutenant in the Royal Marine Light Infantry. He entered the service of the company in 1920. After passing through the shops he was engaged on outside contracts at home and abroad. He was appointed advisory director in 1930 and became a member of the board in 1932. He travelled widely, first in the company of his father, the late Sir Tom Callender, and later alone to India, South Africa and the West Indies. When in Trinidad he visited the famous Pitch Lake, the product of which played a great part in the insulating side of the cable business developed by his grandfather.

## Personal and Business

LORD EUSTACE PERCY has been elected President of the Royal Institution of Great Britain.

MR. W. E. ROOTES has been re-elected President of the Society of Motor Manufacturers and Traders.

MR. DONALD SMITH has been appointed by the Greenock Harbour Trustees as acting general manager of the harbour undertaking.

MR. A. R. SMITH and Mr. H. S. Cooper, who have shared the executive direction of Ford Motor Company, Ltd., since January, 1939, have now been appointed managing directors of the company.

MR. J. S. NICHOLL has been elected President of the Institute of Transport for 1941–42, and Sir Charles Bressey, Messrs. H. M. Cleminson, Ashton Davies, G. Mills, E. J. Missenden and R. S. Pilcher have been elected Vice-Presidents.

THE London Midland and Scottish Railway has announced the following appointments:—Mr. R. C. Bond, to be works superintendent, Crewe (locomotive); Mr. G. S. Bellamy, to be acting mechanical and electrical engineer, Glasgow; and Mr. J. Rankin, to be works superintendent, Derby (locomotive).

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

**Association of Scientific Workers**

*Saturday and Sunday, May 24th and 25th.*—Imperial Hotel, Temple Street, Birmingham, 2. Annual Council meeting. 2.15 p.m. (Saturday) and 10 a.m. (Sunday).

**Institute of Metals**

*Wednesday, May 28th.*—New Clarendon Laboratory, Parks Road, Oxford. May Lecture, "The Significance of Low-temperature Research," F. Simon. 3.30 p.m.

**Institution of Automobile Engineers**

*Tuesday, May 27th.*—12, Hobart Place, S.W.1. "Automobile Research," W. A. Tookey and E. Giffen. 6.30 p.m.

**Institution of Electrical Engineers**

*Monday, May 26th.*—Savoy Place, Victoria Embankment, W.C.2. Discussion, "Looking Forward," to be opened by J. R. Beard. 6.30 p.m.

*Friday, June 6th.*—METER AND INSTRUMENT SECTION: Waldorf Hotel, Aldwych, W.C.2. Informal luncheon. 12.40 for 1 p.m.

**Institution of Mechanical Engineers**

*Friday, May 23rd.*—Storey's Gate, Westminster, S.W.1. "Railway Refrigeration Problems," F. C. Johansen. 6 p.m.

**Royal Society of Arts**

*Wednesday, May 21st.*—Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Fire Prevention Under War Conditions," Lieut.-Colonel Guy Symonds. 2.30 p.m.